DESIGN OF A 24 FOOT CONCRETE PAVEMENT

BY

P. A. HERTWIG

H. E. ANDERSON

ARMOUR INSTITUTE OF TECHNOLOGY

1920

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The design and cost of a 24
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The Design and Cost of a 24 Foot Concrete Pavement; for Skokie Road, Glencoe, Illinois

A THESIS

PRESENTED BY

Fred A. Hertwig - Homer E. Anderson

TO THE

PRESIDENT AND FACULTY
OF
ARMOUR INSTITUTE OF TECHNOLOGY

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APPROVED:

Alfred E. Phillips
PROFESSOR OF CIVIL ENGINEERING

H. M. Raymond
DEAN OF ENGINEERING STUDIES

DEAN OF CULTURAL STUDIES

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We wish to thank Professors Phillips, Armstrong and Reinert for their many helpful suggestions and consultations in the course of completing this thesis. Mr. George A. Quinlan, County Highway Superintendent of Cook County, suggested this section of road for a thesis and gave us much valuable assistance.

OBJECT

The following thesis represents the earnest efforts of the authors to analyze, survey and design a pavement to suit the condition mentioned in the succeeding pages with the minimum of cost and labor.

This thesis was undertaken by the authors to gain thoro knowledge of modern road construction. Having had experience in the construction of highway work, we were desirous of getting the original survey and design phase of highway construction.

At the suggestion of Mr. George A. Quinlan, Cook County Highway Superintendent, we chose this section as it seemed to be a typical and comprehensive section.

Skokie road,as the improvement is called, starts at Vernon Avenue, a twenty foot (20') tar bound macadam road, and runs west a distance of about 2000 feet to a new section of eighteen feet (18') concrete road. It's Vernon Avenue beginning is about three (3) blocks from the Glencoe City Hall and runs to the city limits.

The road at present is a sixteen (16'), water bound macadam pavement, in a very bad condition. It is so bad that most traffic makes a detour in order to avoid it. This road is the only remaining weak link in the

county road system this section of the county. It connects up with the main road to Wheeling and also the Waukegan road which is but three miles west. The traffic using this system consists of a large number of tourists and short-haul trucks. Many of these trucks carry very heavy loads of freight or produce and travel at rates of speed far in excess of the county truck speed laws. The new Cook County speed laws state that a truck up to five thousand pounds (5000#) shall not exceed twenty-five (25) miles per hour on pneumatic tires, and twenty (20) miles on solid tires. Trucks from five thousand pounds (5000#) to twelve thousand pounds (12,000#), twenty (20) miles on pneumatic and fifteen (15) miles on solid tires; and for all trucks in excess of twelve thousand pounds (12,000#) twelve (12) miles per hour. During freight or coal strikes this road is constantly used by hundreds of these large truck trains plying between Chicago and the small towns to the north and west of Glencoe, even as far as Waukegan and Kenosha.

The pleasure automobiles are large in number - due to the presence of many country clubs and several forest preserve tracts on the system of which this is an integral part.

This improvement as originally projected was to be an eighteen foot (18') concrete pavement as it is one of a large number chosen by the country for new construction. Upon hearing that the county planned this improvement, the city of Glencoe decided to try and have this made a twenty-four foot (24') integral curb concrete street pavement in conjunction with the county. It was favored by the county engineers with result that it was agreed that the county should pay for the survey, grading and placing of an eighteen (18) strip of concrete pavement and the cost of the additional width and curbs to be assumed by the city of Glencoe. Any additional costs arising from changing the eighteen (18) foot to the twenty-four (24) foot pavement to be paid for by Glencoe. Concrete was chosen for the pavement as it is the general policy of the county to

improve all trunk highways with concrete.

The benefits of this section of road will be considerable to the adjacent property owners as well as the tourists and commercial vehicle owners. The old pavement in the condition that it is in is very objectionable with its deep ruts that fill with mud and water in wet weather, and its dry dusty surface in dry seasons. It presents a very noticeable contrast to the clean and even artistic effect produced by the interesting streets which are all well paved with tar-bound macadam. Glencoe is reputed to have a very high grade system of street paving. As a result of this, property on an unimproved or poorly paved street, such as Skokie Road, is not considered of as high a class as that on the better streets. There are located on this stretch several fine homes and two large subdivisions. The latter property is very attractively wooded and well drained and with its close proximity, of two blocks, to the Skokie Country Club and famous Skokie marsh, it will prove a great attraction to future home builders

upon the completion of the twenty-four foot (24') integral curb concrete pavement.

The survey of a road for construction or reconstruction consists of a transit line, profile and cross-sections. Stakes are set at every hundred feet, or at intermediate points when necessary, and the number of the station marked on the side of the stake facing the road, while on the opposite side the distance to the center line or transit line is marked. These stakes are placed a distance from the transit line large enough to be undisturbed by traffic or by the construction gangs. The stakes are usually placed on the fence line about thirty feet (30') or so from the transit line. The stakes described above are set on the right side of the road. On the left side of the road stakes are set at every hundred feet, the distance out from the transit line being estimated to be the same as the stake on the right side. Levels are taken on the tops of these stakes and the cut or fill to the nearest tenth of a foot to subgrade is marked upon the side facing the road. The face opposite

the road has the number of the station marked on it. In our survey we omitted these latter stakes as they are useful only when immediate construction takes place.

In establishing our transit line we tried to keep in the center of our "right-of-way" which happened to be sixty-six feet (66'). We started at the end of an eighteen foot (18') concrete road and called that station 0 + 00. This station happened to be on a short tangent, so we continued this tangent until it intersected with the transit line of the road further on, which was taken along the middle of the right-of-way, and in this way got a point of intersection which was at station 0 + 84.5. From this P. I. to station 14 + 36.5 we had a straight stretch of road. At the P. I., station 14 + 36.5, the road takes a turn, the internal angle of which is 147° 30' and then runs straight to Vernon Avenue. Stakes were set at every 100 feet and the number of the station and the distance from the transit line marked

[illegible]

upon them as described above.

Pluses and distances out to fences, telephone poles, light and transmission poles, signs, hydrants, catch-basins, man-holes, water and gas mains, private drive-ways, houses and barns etc. were taken and noted and used in plotting the plan of the road.

When notes for the plan of the road were complete, levels for cross-sections were started. We began at station 0 + 00 at the center of the end of the eighteen foot (18') concrete pavement on the west end of our road and called this B. M. elevation 100.00. Later on we referred this B. M. to Glencoe datum by running a set of levels to the B. M. on the northwest corner of the water-table of the Glencoe City Hall, the elevation of which is 99.67 and found the elevation to be 75.70 ft. Cross-section levels were taken at every fifty feet (50') and at all other places where it was deemed advisable. The cross-sections were

taken to a distance of twenty feet (20') on each side of the transit line, this being considered enough because we are not goingto need side ditches. Cross-sections were also taken on each side of street intersection in order that the grading and intersections could be carefully worked out. Elevations were also taken at street intersections, existing curbs, sidewalks, man-holes, catch-basins, hydrants, water and gas mains and private drive-ways. The intersecting streets are all well paved and the elevations at their junction with the new Skokie Road were necessary to establish the grade line of the new road.

Attention was paid to existing sewers and inlets and complete notes were taken on these, so that they could either be made to serve our pavement or new ones built. Elevations were taken on Vernon Avenue one hundred feet (100') each side of the Skokie Road. An elevation was also taken at the center of the be-

ginning of the brick pavement at Vernon Avenue and Milton for reference. To conclude the field work, snap shots were taken of the whole road, showing the contour, the man-holes and sewer inlets, intersecting streets, etc. and in general conveying a fair idea of what the road looked like before improvement.

DESIGN

In designing we conformed to the Cook County specifications. A new section of these specifications requires the construction of a curved subgrade of the same crown as that of the finished pavement. Personally the authors of this thesis do not approve of this type of construction as it makes far excessive expense for the taxpayer and contractor by adding to the cost of the road with practically no benefit. A flat subgrade is much easier of construction both physically and monetarily.

The form of the curb used is one having a curved batter. It allows the full width of the street to be used as it encourages drivers of cars to stop their machines close to the curb, there being no possibility that the tires and rims can be damaged. The natural tendency is for the driver to stay clear of a curb having a vertical face by as much as one (1) to one and a half (1 1/2) feet so as to avoid injury to his machine. Thus the effective width of the street may be reduced as much as three feet (3') should

two machines stop opposite each other. Since heavy wagons with steel tires back against the curb very often, sharp corners would be chipped off. With the curb with a curved batter, however, this trouble is practically eliminated.

The slab and curb section is shown in detail on a separate sketch. Such a curb is known as integral, because it is a part of the pavement.

THE SLAB .

The slab is a ten inch (10") twenty-four foot (24') portland cement slab with a crown of two inches (2"). According to Blanchard's Highway Engineering and the Portland Cement Association specification for thickness of slab for a twenty-five (25) to thirty (30) foot pavement should be ten inches (10") for one subject to heavy type traffic. Practice in this section is to use a nine inch (9") slab but the authors agree with the above authorities that at least a ten inch (10") slab should be used. The crown was chosen as two inches (2") after much investigation which showed that the general tendency

[illegible]

[illegible]

[illegible]

is to reduce the crown.

Two formulas commonly used are - c = 1/50 W & c = 1/100 W; where c = crown and W=width of pavement in inches. Class "A" concrete is used for the slab and class "X" for the curbing.

SUB - DRAINAGE

An investigation of the soil proved it to be in general a clay and gravel mixture or a sandy loam. With the use of curb an added chance was afforded by it for water to get under the slab and destroy the foundation and, therefore, a sub-drainage system was deemed necessary. The system used was two lines of five inch (5") bell and spigot double strength vitrified sewer pipe. The two pipe lines were put at eleven and one-half feet (11 1/2') each side of the center line so as to catch all water as it enters from the sides. The trench is three feet (3') six inches (6") deep on a grade parallel to the top of the metal. Outlets to the storm sewer were inserted at each end of the

line. Three foot (3') shoulders were designed at a six (6) to one (1) slope from the curb to support the curb and also to protect the subgrade by keeping out the surface water. These shoulders were taken as falling away to a one (1) to one (1) slope at there outside edge.

PLAN AND PROFILE

PLAN

In drawing the plan and profile a scale of two and one-half inches (2 1/2") = one hundred feet (100') was used for the plan; and one inch (1") = four feet (4') vertical. Besides the transit line the old right of way and intersecting streets and alleys were plotted,as were the sewer inlets, man-holes, hydrants, light and power poles, right of way and property lines and sidewalks. Curves were figured for the break in transit line and noted on the plan. The proper P. C's and P. T's for the streets, alleys and private drive-ways were calculated on a basis of two feet (2') radius curves for the alleys and private streets and curves of varying radius for the streets as shown on the plans. Curbing was omitted at all streets, alleys and private drive-ways to permit of leaving the surface of the improvement.

SURFACE DRAINAGE

The surface drainage was designed so that no water had an unchecked run of more than two

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

hundred and fifty feet (250') (half an ordinary block) and none crossed any intersecting streets. One of the old catch-basins and its inlet was discarded and filled in. All other changes in inlets were adjusted by placing the inlet in the curb and connecting to the adjacent catch-basin, which we recovered with a man-hole top instead of an inlet. The type of inlet used was an oblong gutter grating. This type of inlet was used because it afforded an easy connection to the existing man-holes.

One new inlet was placed at station 0 + 05 in the north curb as the wash of water for two hundred twenty (220) from the one at station 2 + 20 was feared would destroy the shoulder of the eighteen foot (18') concrete road with which our pavement joins. The new locations of the inlets and the new elevation of the man-holes and inlets were tabulated with the amount of connecting pipe required for each in the seperate table furnished.

PROFILE

The profile of the old road was plotted and then a grade line was suited to it that would meet the grades of the intersecting streets best. This necessitated in some case an excess of cut,but it can easily be wasted in filling up the parkway between the shoulders and the sidewalk or sidewalk line. This will eliminate the necessity of property owners filling this in at a much greater expense. After the grade line was adjusted and the P. I's located, the vertical curves were calculated and recorded on the profile. The maximum grade is 4.0 % and the minimum grade 0.00%.

CROSS SECTIONS

With the grade line adjusted, we now were able to plot our cross sections. The natural surface sections were plotted first and then , at the corresponding grade line elevation of each section station, we drew in our metal section and also shoulders. This was greatly aided by the use of a celluloid template which

we constructed to scale to the exact dimensions of the slab, curbs and shoulders. When plotted the amount of fill to support the cut and amount of cut to allow its construction were calculated by finding the end area on fifty foot (50') sections.

COST

These costs were prepared from current prices at Glencoe, Ill. May 18, 1920. The unit costs were kindly furnished to the authors by Mr. Barker, construction engineer, Cook County Highway Department; Wm. E. Dee Tile Co. and T. A Cummings Foundry Co.

In making cost estimates at a time when conditions are as changeable and uncertain as they are now, an estimate is subject to such variation that a twenty-five (25) per cent profit and overhead cost was used in our computations. The authors realize that this cost estimate is not complete in all the small details as that is the work of an expert estimater, and would require more time than we had available.

DEPARTMENT C

Itemized Estim

P.C. CO

ON Dirt

Improvement to begin Sta 0 + 00 to end Sta 19 + 50

Length to be improved 1950 ft. width 24 ft.

Areas: Pavement 1,675 sq. yds. Earth Shoulders

MATERIALS	Quantity	
Cement for Pavement or Base & Gutter	928	bbls
Fine Aggregate for Concrete	289	cu.
Coarse " " "	492	"
Water	1,675	sq.
Forms	1,200	lin.
Bituminous Materials for Pavement		gals
Filler		100
Fine Aggregate for Macadam Base		cu.
Coarse " " " "		"
Man-Hole Covers	16	
Inlets	16	
Cost of Materials		

LABOR: Cost per hour; men cts. Teams

Average haul miles.

Unloading Cement	928	bbls
Hauling "	928	"
Loading Fine Aggregate	289	cu.
Hauling " "	289	"
Loading Coarse "	492	"
Hauling " "	492	"
Unloading Fine " for Wearing Surface		"
" Coarse " " " "		"
Hauling Bituminous Mixture		tons
Superintendence	1,675	sq.
Shaping and Rolling Subgrade	1,675	"
Mixing and Placing Concrete, Forms, etc	1,675	"
Covering, Seasoning and Cleaning Pavement	1,675	"
Spreading Stone and Screenings		"
Rolling and Sprinkling Macadam Base		"
Heating, Mixing and Placing Bituminous Concrete		"
Construction Cost, Curb & Gutter	128.5	cu.
Setting M.H. & Inlets		
Cost of Materials and Labor		

Shaping and Rolling Shoulders, Gutters, etc	1,233	sq. y
Excavation	1,675	cu.
Borrow (miles)		"
Rip Rap, Complete in Place		sq.
Tile, Drain, complete (5 inch) str.	3,940	lin. f
" " " (5 ") cur.	16	"
" " " (9 ") str.	204	"
" " " (9 ") cur.	64	"
Concrete Gutter (")		"
Concrete in Bridges, Culverts, Walls, etc.		cu. y
Reinforcing Steel for Bridges, Culverts, Walls, etc		lbs.
Guard, Fence		lin.
Brick, Hand Rail		cu. y
Section Markers		mark
Temporary Roads and Bridges		miles
Engineering and Seeding		"
Excavation For Sub Drain	552	cu.

Total Cost, exclusive of Profit and Overhead

Profit and Overhead 25 per cent

Total Cost of Road

Contract Price

107341

Form 22

21A

COOK COUNTY
DEPARTMENT OF HIGHWAYS
Itemized Estimate of Cost of
P. C. CONCRETE ROAD

Road Skokie Road
Section 64
Route 4

ON Dirt BASE

Improvement to begin Sta 0 + 00 to end Sta 19 + 50 Money available, $

Length to be improved 1950 ft. width 24 ft. with 3.0 ft. Earth Shoulders.

Areas: Pavement 1,675 sq. yds. Earth Shoulders 1,233 sq. yds. Concrete gutters lineal ft.

MATERIALS	Quantity			Unit Cost		Total Cost	Per sq. yd.
Cement for Pavement or Base & Gutter	928	bbls	@	2.18	per bbl.	$ 2120 00	
Fine Aggregate for Concrete	289	cu. yds.	@	2.50	" cu. yd.	723 00	
Coarse " " "	492	" "	@	2.25	" " "	1108 00	
Water	1,675	sq. "	@	0.06	" sq. "	100 50	
Forms	1,200	lin. ft.		0.75		900 00	
Bituminous Materials for Pavement		gals	@		per gal.		
Filler		100 ft.	@		" 100 ft.		
Fine Aggregate for Macadam Base		cu. yds.	@		" cu. yd.		
Coarse " " " "		" "	@		" " "		
Man-Hole Covers	16		@	25.00		400 00	
Inlets	16		@	11.25		180 00	
Cost of Materials						$ 5531 50	
LABOR: Cost per hour; men cts. Teams cts. Average haul miles.							
Unloading Cement	928	bbls	@	0.04	per bbl.	37 10	
Hauling "	928	"	@	0.04	" "	37 10	
Loading Fine Aggregate	289	cu. yds.	@	0.20	" cu. yd.	57 80	
Hauling " "	289	" "	@	0.30	" " "	86 70	
Loading Coarse "	492	" "	@	0.25	" " "	123 00	
Hauling " "	492	" "	@	0.30	" " "	147 60	
Unloading Fine " for Wearing Surface		" "	@		" " "		
" Coarse " " " "		" "	@		" " "		
Hauling Bituminous Mixture		tons	@		" ton		
Superintendence	1,675	sq. yds.	@	0.07	" sq. yd.	117 25	
Shaping and Rolling Subgrade	1,675	" "	@	0.12	" " "	201 00	
Mixing and Placing Concrete, Forms, etc	1,675	" "	@	0.45	" " "	763 75	
Covering, Seasoning and Cleaning Pavement	1,675	" "	@	0.06	" " "	100 50	
Spreading Stone and Screenings		" "	@		" " "		
Rolling and Sprinkling Macadam Base		" "	@		" " "		
Heating, Mixing and Placing Bituminous Concrete		" "	@		" " "		
Construction Cost, Curb & Gutter	128.5	cu. yds.	@	3.00	" cu. yd	384 05	
Setting M. H. & Inlets			@			150 00	
Cost of Materials and Labor						$ 7737 35	
Shaping and Rolling Shoulders, Gutters, etc	1,233	sq. yds.	@	0.10	per sq. yd.	123 30	
Excavation	1,675	cu. "	@	1.50	" cu. "	2508 00	
Borrow (miles)		" "	@		" " "		
Rip Rap, Complete in Place		sq. "	@		" sq. "		
Tile, Drain, complete (5 inch) str.	3,940	lin. ft.	@	0.225	lin. ft.	886 50	
" " " (5 ") cur.	16	" "	@	0.90	" "	14 40	
" " " (9 ") str.	204	" "	@	0.525	" "	107 10	
" " " (9 ") cur.	64	" "	@	2.10	" "	134 40	
Concrete Gutter (")		" "	@		" "		
Concrete in Bridges, Culverts, Walls, etc		cu. yds.	@		cu. yds.		
Reinforcing Steel for Bridges, Culverts, Walls, etc		lbs.	@		per lb.		
Guard, Fence		lin. ft.	@		lin. ft.		
Brick, Hand Rail		cu. yds.	@		cu. yd.		
Section Markers		markers	@		per marker		
Temporary Roads and Bridges		miles	@		per mile		
Engineering and Seeding		"	@		" "	225 00	
Excavation For Sub Drain	552	cu. yds.	@	1.70	" cu. yd.	938 40	
Total Cost, exclusive of Profit and Overhead						$ 12674 45	
Profit and Overhead 25 per cent						$ 3168 61	
Total Cost of Road						$ 15843 06	
Contract Price						$	

Computed H. E. A.

Checked F. A. H.

Date May 18, 1920

Approved

Assistant Engineer.

STA	SECTION AREA		END AREA		YARDAGE		REMARKS
	- CUT	+ FILL	- CUT	+ FILL	- CUT	+ FILL	
0+00	19.0	5.0	69.50	5.0	64.40	4.64	
0+50	50.5	0.0	99.50	0.0	59.70	0.00	
0+84	49.0	0.0	92.70	0.0	27.50	0.00	
1+00	43.7	0.0	69.65	1.6	64.50	1.47	
1+50	25.95	1.6	44.40	4.85	41.20	4.50	
2+00	18.45	3.25	31.35	7.75	29.00	7.18	
2+50	12.9	4.5	31.50	9.12	24.20	8.45	
3+00	18.6	4.62	34.70	6.12	32.10	5.66	50' Deduct for Bluff St intersec
4+00	16.1	1.50	21.20	9.30	19.60	8.60	
4+50	5.1	7.8	7.90	17.30	7.30	16.00	
5+00	2.8	9.5	4.30	20.50	3.98	19.00	
5+50	1.5	11.00	6.75	13.50	6.25	12.50	
6+00	5.25	2.50	10.50	5.75	9.71	5.32	
6+50	5.25	3.25	10.75	4.75	9.90	4.40	
7+00	5.50	1.50	10.00	8.70	9.25	8.05	
7+50	4.50	7.20	9.80	13.95	9.08	12.95	
8+00	5.30	6.75	17.80	10.50	16.50	9.71	
8+50	12.50	3.75	26.40	7.75	24.40	7.17	
9+00	13.90	4.00	27.15	12.70	25.00	11.75	
9+50	13.25	8.70	25.65	14.70	23.70	13.60	
10+00	12.40	6.00	26.50	11.00	24.30	10.20	
10+50	14.10	5.00	34.80	10.50	32.20	9.71	
11+00	20.70	5.50	60.20	5.50	55.70	5.09	
11+50	39.50	0.0	92.20	0.00	85.60	0.00	
12+00	52.70	0.0	91.70	0.00	84.70	0.00	
12+50	39.00	0.0	58.70	2.00	54.30	1.85	
13+00	19.70	2.0	32.40	8.00	30.00	7.40	
13+50	12.70	6.0	21.70	15.20	20.10	14.10	
14+00	9.00	9.20	18.20	18.57	12.30	12.53	
14+36.5	9.20	9.37	43.90	9.67	50.80	11.20	50'Deducted for St intersection.
15+24	34.70	0.30	103.20	0.30	145.00	0.42	
16+00	68.50	0.0	120.00	0.00	111.00	0.00	
16+50	51.50	0.0	93.21	0.00	86.30	0.00	
17+00	41.70	0.0	71.70	1.00	66.40	0.92	
17+50	30.0	1.0	66.75	1.00	61.70	0.92	
18+00	36.75	0.0	72.25	0.00	67.70	0.00	
18+50	35.50	0.0	69.75	0.00	64.70	0.00	
19+00	34.25	0.0	68.87	0.00	63.80	0.00	
19+49	34.62	0.0	59.12	0.88	1.09	0.01	
19+50	24.50	0.8					
				TOTAL =	1,619.96	235.30	

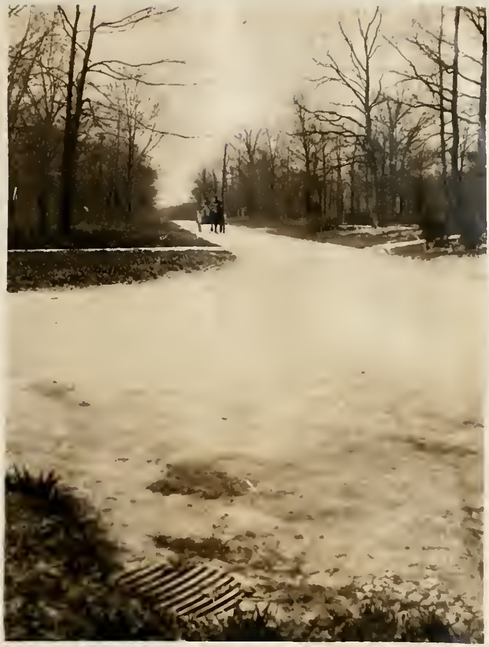
MANHOLE & INLET DATA.

STA.& POSITION OF M.H.	M.H. ELEVATION		STA.& POSITION OF INLET	INLET ELEV.	LENG. 9" VIT. SEWER PIPE INLET TO M.H.
	OLD	NEW			
0+68.5 C	102.53	101.39	0+05 N	99.86	68'
1+08 S	103.36	102.80	1+04 S	102.60	12
2+26 N	107.36	107.48	2+22 N	107.32	12
2+26 S	107.49		2+22 S	107.32	12
3+27 N	111.60	111.52	3+23 N	111.36	12
3+61 S	112.38	112.88	M.H. ONLY		
3+72.5 S	112.40	113.34	3+76.5 S	113.48	12
5+20 N	117.82	118.19	5+16 N	118.09	12
6+36 N	118.64	119.30	6+40 N	119.32	12
6+58 S	119.06	119.46	6+62 S	119.46	16
9+16 N	120.02	120.46	9+22 N	120.49	12
9+54 S	119.26	120.61	9+58 S	120.64	12
11+40.8 C	121.30	120.96	M.H. ONLY		
11+98 S	120.86	120.92	12+02 S	120.95	12
11+98 N	120.02	120.92	12+02 N	120.95	12
14+90.5 S	123.77	123.59	M.H. ONLY		
16+80.4 C	122.16	121.53	" " "		
17+25.5 N	120.16	120.12	17+21.5 N	120.16	12
17+25.5 S	120.11	120.12	17+21.5 S	120.16	12
17+36.5 C	120.91	120.08	M.H. ONLY		
19+63.5 N	115.93	116.10	19+59.5 N	116.00	12
19+65 S	115.71	116.20	19+59 S	116.00	16

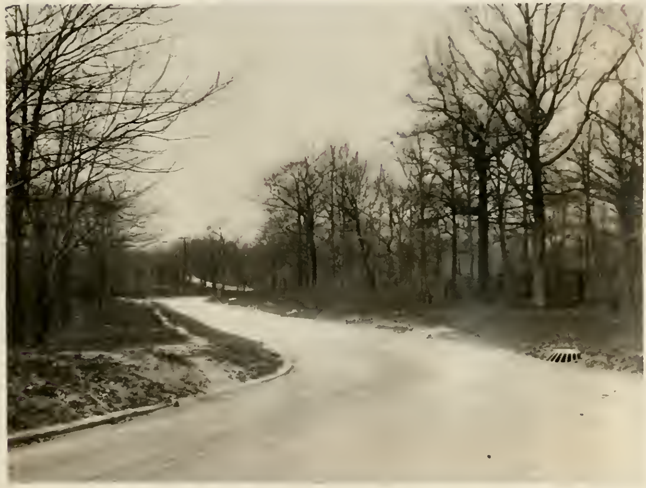
MANHOLES: COVERS,
T.A. CUMMINGS FOUNDRY CO., 25" DIAM. #13.

INLETS:
T.A. CUMMINGS FOUNDRY CO., GUTTER BOX #16.

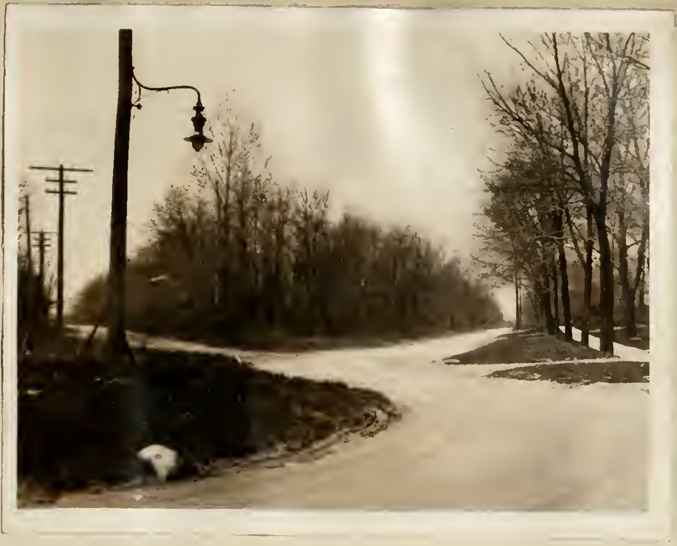
TOTAL LENG. 9" PIPE:
268'



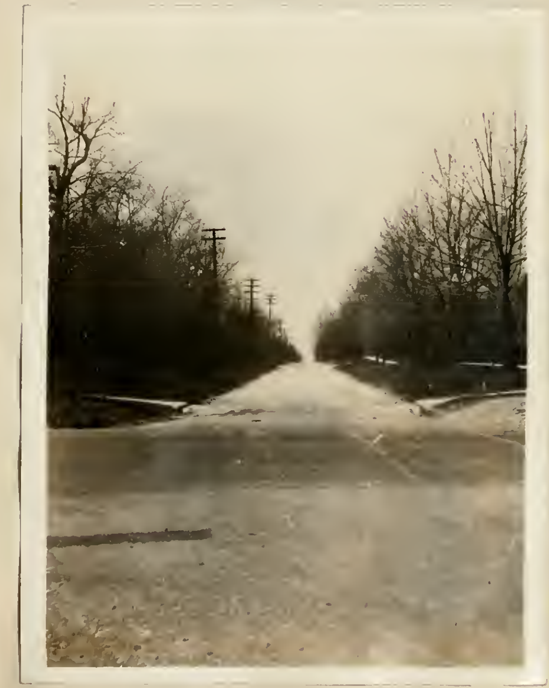
Cor. Grove and Skokie, looking west.



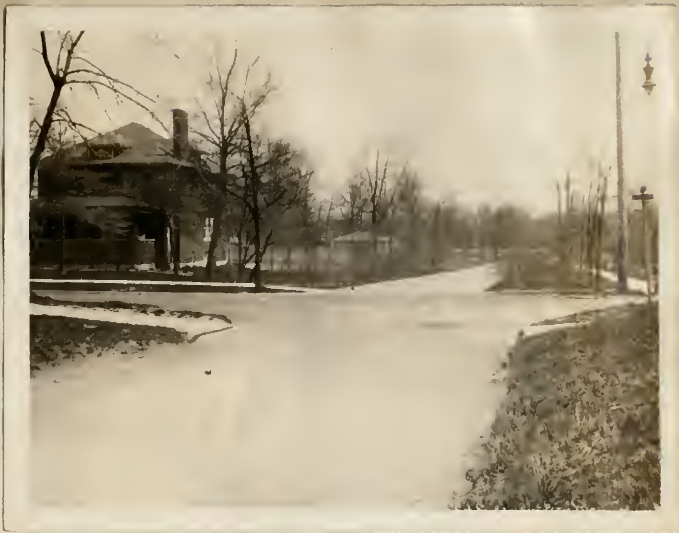
Looking west from Bluff St. to sta. 0+ 00



Looking west from Greenwood and Milton.

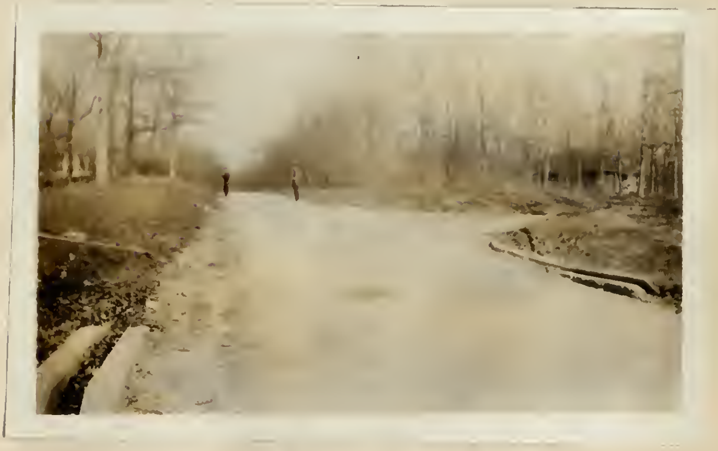


Looking west from Vernon and Milton.

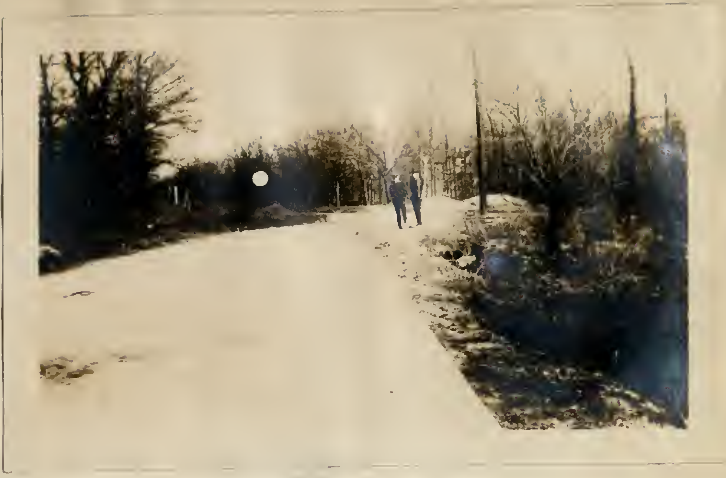


Looking east toward Vernon Ave

End of improvement.

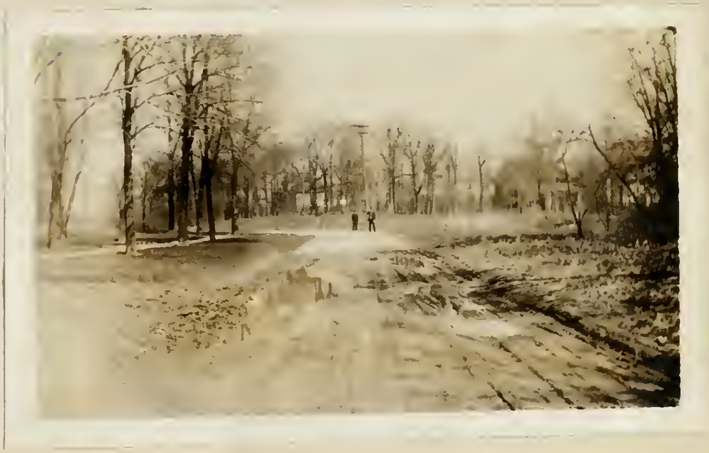


Skokie Rd. showing old curbs and cross-walks.



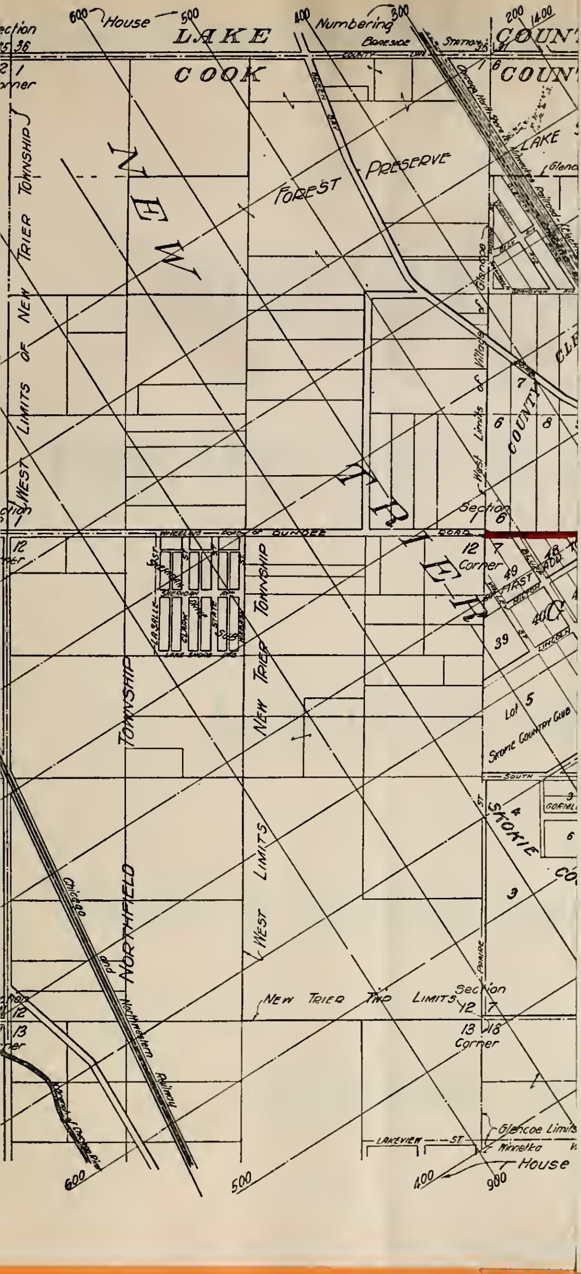
Looking east toward sta. 0+00

Sign shows Glencoe city limits.

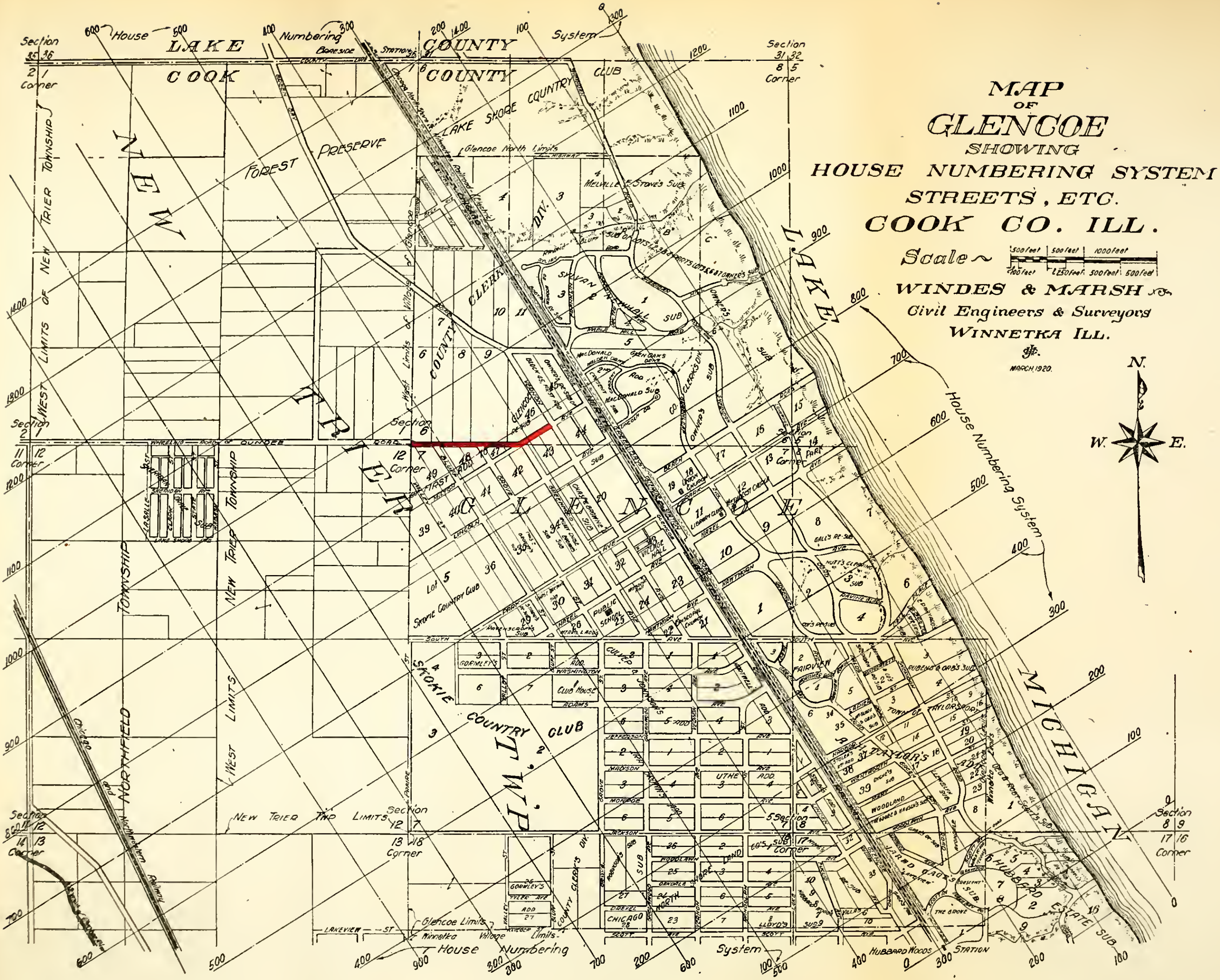


Looking east from sta. 12+ 00

Note bad ruts.



FEBRUARY 1920

# MAP OF GLENCOE

SHOWING

HOUSE NUMBERING SYSTEM

STREETS, ETC.

COOK CO. ILL.

Scale ~

WINDES & MARSH

Civil Engineers & Surveyors

WINNETKA ILL.

MARCH, 1920.

SPECIFICATIONS

FOR

HIGHWAY PAVEMENTS

COUNTY OF COOK

GEORGE A. QUINLAN, Superintendent of Highways

CHICAGO, ILLINOIS

FEBRUARY 1920

3426

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GENERAL SPECIFICATIONS

DEFINITIONS OF TERMS.

1. Wherever the term "County" or "Board" is used in this contract, it is understood to mean the Board of County Commissioners of Cook County, Illinois, party of the first part to this contract, or its authorized representative limited by the particular duties entrusted to him.

2. Wherever the term "Contractor" is used, it is understood to mean the person or persons who entered into this contract as party or parties of the second part his or their heirs, executors, administrators, successors or assignees.

3. Wherever the term "Engineer" is used, it is understood to mean the County Superintendent of Highways of Cook County, or his authorized representative.

4. Wherever the term "Inspector" is used, it is understood to mean the person employed by the County Department of Highways to perform such duties as are herein described as duties of the Inspector.

5. Wherever the word "Plans" is used, it is understood to mean all drawings, or reproduction of drawings pertaining to the construction involved.

6. Wherever the word "Specifications" is used, it is understood to include all directions and requirements contained herein, together with all special provisions and written agreements made or to be made pertaining to the work involved. All articles referred to in these specifications when not qualified otherwise than by numbers shall be understood to be articles from these specifications.

7. It is further understood that all things contained herein, the "Notice to Contractors," the "Instructions to Bidders," the "Award and Execution of Contract," the "General Clauses," the "Construction Details," and also the "Plans," the "Proposal," the "Contract," the "Bond," as well as any special provisions attached to or bound with any of the above, also any and all supplemental agreements made or to be made are hereby made a part of these specifications and contract.

GENERAL INSTRUCTIONS TO BIDDERS

8. **Interpretation of the Estimate.** The attention of the bidder is called to the fact that the estimate of quantities given in Article 15 of the proposal is believed by the Board of County Commissioners to be correct, but is given only as a guide in checking such estimates as the bidder may make, and as a basis of calculation, upon which the award of the contract is to be made.

9. While the quantities are believed to be correct, they are intended to be merely descriptive of the work, and in case of any discrepancy between the plans and the quantities enumerated in article 15 of the "Proposal," the plans shall prevail.

10. In addition to the quantities as stated, there is included all grading, shaping and trimming roadbed, roadsides and ditches, constructing all drainage work, furnishing all materials, complete in place, furnishing all tools, labor and supplies, and the performance of all incidental work necessary to complete the proposed construction in accordance with the plans and specifications herein referred to or hereto attached. If any materials or machinery are to be furnished the Contractor by the County of Cook, there will be inserted under "Special Provisions" articles describing the materials or machinery and stating the conditions under which they are to be furnished.

11. In case the Engineer decides to extend or shorten the improvement or otherwise to alter it by extras or deductions, the bidder agrees to make such changes for the additive or subtractive consideration obtained by applying the unit prices to the quantities of the several items of work that may be involved by reason of such change, including the elimination of any one or more of the items.

12. **Examination of the Site, Plans, Specifications, Etc.** The bidder should examine to his satisfaction the site of the proposed work and should also satisfy himself as to the quantities of work to be done as determined from the plans. He should be thoroughly familiar with the specifications, including all special provisions, and the contract forms.

13. **Contents of Proposal Form.** All proposals shall be made on the forms furnished by the County Superintendent of Public Service and shall specify the unit price for each item of work, and also the gross sum for which all the proposed work will be done. In case of discrepancy between the gross sum as submitted and the one obtained from the several unit prices, the latter shall be held to prevail if the proposal is not rejected as irregular.

14. All proposals otherwise submitted may be rejected as irregular; also unbalanced proposals, and proposals in which the gross sum as submitted does not agree with the one obtained from the several unit prices.

15. Only sealed bids will be considered.

16. Bids exceeding the Engineer's estimate will not be considered.

17. **Irregular Proposals.** Proposals may be rejected as informal if they show omissions, alterations, erasures, additions not called for, conditional bids or irregularities of any kind.

18. **Certified Check.** All proposals for work on which the Engineer's estimate as advertised is $6,000.00 or less, shall be accompanied by a certified check for the sum of Three Hundred Dollars ($300.00).

19. All proposals for work on which the Engineer's estimate as advertised exceeds $6,000.00, shall be accompanied by a certified check for the sum of five (5) per cent of said estimate.

20. All proposals for work on which the Engineer's estimate is not advertised shall be accompanied by a certified check for the sum of five (5) per cent of the gross sum bid in Article 15 of the Proposal, but in no case will a certified check for less than Three Hundred Dollars ($300.00) be considered.

21. All proposals submitted to cover more than one section shall be accompanied by a certified check for each section for the same sum as is required for each section when proposals are submitted separately.

22. All certified checks shall be made payable to the order of Peter Reinberg, President, County Board.

23. **Delivery of Proposals.** Proposals shall be sealed in envelopes provided by the Superintendent of Public Service for the purpose and endorsed:

PROPOSAL FOR ROAD WORK.

Township............................ Contract No............

Section..............................

Route (s)...........................

24. Proposals sent by mail shall, in addition to being sealed in an envelope provided for this purpose, be enclosed in a second or outer envelope addressed:

COUNTY SUPERINTENDENT OF PUBLIC SERVICE,
519 COUNTY COURT HOUSE,
CHICAGO, ILLINOIS.

25. **Opening of Proposals.** Bids will be opened at the time and place specified in article 1 of the "Notice to Contractors." Bidders, their authorized agents, and interested parties are invited to be present at the opening of the proposals.

26. **Disqualification of Bidders.** More than one proposal from an individual, a firm or partnership, a corporation or an association under the same or different names will not be considered. Reasonable ground for believing that any Bidder is interested in more than one proposal for the work contemplated will cause the rejection of all proposals in which such Bidder is interested. Any or all proposals will be rejected if there is reason to believe that collusion exists among the Bidders and all participants in such collusion will not be considered in future proposals for the same work. Proposals in which the prices obviously are unbalanced will be rejected. No contract will be awarded except to responsible bidders capable of performing the class of work contemplated.

AWARD AND EXECUTION OF CONTRACT.

27. **Right to Reject Proposals.** The Board of County Commissioners reserves the right to reject any or all proposals and to waive technicalities.

28. **Award of Contract.** The contract will be awarded by the Board of County Commissioners, subject to the approval of the State Department of Public Works and Buildings, as soon after the opening of bids as practicable. The successful bidder, if not present, will be notified by mail of the award.

29. **Credentials.** At the time of submitting proposals the Contractor should furnish proper credentials to the Board of County Commissioners as to his financial resources, his experience and his ability to complete the contract in a satisfactory manner. Failure to do this may cause delay in the award of the contract until such information can be obtained.

30. **Return of Certified Check.** The checks of the three lowest bidders shall be retained only until the Contractor's bond is approved and all other checks shall be returned immediately to the respective bidders.

31. **Bond.** Before entering into a contract, the Contractor shall execute a bond in the form prescribed by the Board of County Commissioners in the penal sum of the amount of the contract with a Surety Company to be approved by the Board of County Commissioners, such bond to be conditioned that the contractor will perform the work in accordance with the terms of the contract and with the plans and specifications and that he will commence and complete the work within the time prescribed in the contract.

32. Such bond shall also provide against any direct or indirect damages that may be suffered or claimed on account of such construction or improvement during the time thereof and until the work is accepted; provided the full amount of such bond shall be conditioned also upon the payment by the Contractor of all sums of money due for any labor, materials, apparatus, fixtures or machinery furnished to such Contractor for the purpose of such construction or improvement. It is understood that the full amount of the bond shall inure to the benefit of any person to whom any money may be due for any such labor, materials, apparatus, fixtures or machinery so furnished, and suit may be maintained on such bond by any such person for the recovery of any such money.

33. **Execution of Contract.** The Contract shall be executed in triplicate and filed in the office of the County Superintendent of Public Service within ten (10) days after the awarding of the contract.

34. **Failure to Execute Contract.** Should the successful bidder fail to execute a contract and file a bond within ten (10) days of the date of acceptance of his proposal, his certified check shall become the property of the County of Cook and will be considered as payment of damages due to delay and other causes suffered by the County from the refusal to execute a contract.

35. **Subletting Contract.** The Contractor shall give his personal attention to this contract and shall not sublet the same or any portion thereof without the written consent of the Board of County Commissioners.

36. **Patented Devices.** The Contractor shall indemnify, keep and save harmless the County from all liabilities, judgment or cost and expenses which may in any wise come against the said County on account of infringement of any patent covering the use of any design, material, machinery, device, or apparatus used in the performance of this contract.

GENERAL CLAUSES

37. **Work to be Done.** The work to be done includes the furnishing of all materials, machinery, tools, supplies, labor and other means of construction necessary to do all the work in connection with the construction or improvement herein described; including all grading, shaping and trimming roadbed, roadsides and ditches, constructing all drainage work, and the performance of all incidental work necessary to complete the proposed construction or improvement in accordance with the plans and specifications herein referred to or hereto attached and the requirements of the Engineer under them.

38. **Materials and Machinery Furnished by the County.** If any materials or machinery are to be furnished the Contractor by the County of Cook, there will be inserted under "Special Provisions" articles describing the materials or machinery and stating the conditions under which they are to be furnished.

39. **Permits and Licenses.** All permits and licenses required to complete the work shall be obtained by the Contractor at his expense.

40. **Change in Plans.** Changes in plans or specifications shall not be made by the Contractor unless so authorized in writing by the Engineer.

41. **Interpretation of Plans and Specifications.** In the event of a discrepancy between any drawing and the figures written thereon, the figures shall be taken as correct. In case of any discrepancy between any drawing and the specifications, the specifications are to govern, except as provided in article 9 of these specifications.

42. **Special Work.** Any special provisions or requirements not covered by the standard specifications will be inserted on separate sheets.

43. All special or supplementary specifications shall prevail even though they conflict with the standard specifications of which they are a part.

44. **Alteration of Work.** The right is reserved by the party of the first part to make such changes in the plans and specifications as may from time to time appear necessary or desirable, and such changes shall in no wise invalidate the contract.

45. **Additional Work or Deductions.** The Contractor hereby agrees to such additions, deductions or other alterations to the quantities, as listed in article 15 of the Proposal, as may be necessary for the proper completion of the work, and it is understood that he shall make such changes for the additive or subtractive consideration obtained by applying the unit prices to the quantities of the several items of work that may be involved by such change, except as otherwise provided in these specifications.

46. **Extra Work.** Should it be necessary in the opinion of the Engineer to do work not covered by the plans and specifications, other than that provided for in article 45, the Contractor agrees to do such work for the actual cost of same plus fifteen (15) per cent. Actual cost, it is understood and agreed, includes all necessary labor at the regular prices paid therefor, and the actual cost to the Contractor of all materials as shown by properly authenticated bills. No charge shall be made by the Contractor for organization or overhead expense, nor shall any charge for superintendence be made except when there shall be necessarily employed on the proposed extra work at any time and in one place to exceed five (5) laborers, in which case a foreman may be employed and his actual expense to the Contractor charged to the extra work for the actual time employed.

47. Payment shall not be made for rental or depreciation of machinery or other equipment unless there is required to perform the extra work equipment not required in the original work, in which case a written agreement shall be made as to the amount to be allowed for rental and depreciation.

48. The Contractor agrees to present to the inspector in charge his daily expense record for examination and at least once each month present an itemized signed statement, showing the actual cost of each separate piece of extra work, which shall be approved by the Engineer before payment is made. Allowance for extra work shall be made only upon the written order of the Engineer.

49. **Unauthorized Work.** Except as provided in articles 45 and 46, no allowance shall be made for work done beyond the lines and grades shown on the plans.

50. **Progress of Work.** The work shall begin not later than fifteen (15) days after the date of notice to begin work and shall be diligently prosecuted at such a rate and in such manner as in the opinion of the Engineer is necessary for its completion within the time herein specified, it being understood that time is of the essence of this contract.

51. The Contractor shall notify the Engineer in writing at least seven (7) days in advance of the date he expects to begin work and shall also notify the Engineer in writing of the time the work is ready for final inspection.

52. The Contractor shall be charged for the salary and expenses of the Inspector from the date he has set for starting work until actual work is commenced. If the Contractor is delayed in starting work by the non-arrival of the Inspector, he shall be allowed an extension of time for the completion of his contract equal to the time that he is delayed.

53. Should the Contractor fail to begin the work at the proper time, or to maintain the necessary force and equipment, or if it becomes evident to the Engineer that the work is not being prosecuted with due diligence, or will not be completed within the contract time, it is hereby understood that the Board of County Commissioners may call upon the Bonding Company to bring the work to a satisfactory completion in accordance with the terms of the contract; or if agreeable to the Bonding Company, the Board of County Commissioners may re-let the remaining portion of the work, or employ such additional labor and purchase such additional tools and materials, as may seem essential to insure the completion of the work within the contract time. The total cost of the work thus done, including the cost of labor, tools, and materials, shall be deducted from any moneys due, or to be come due the Contractor, or covered by the bond for fulfillment of the contract.

54. **Character of Workmen and Equipment.** Any foreman or workman employed by the Contractor or by any Sub-contractor, who in the opinion of the Engineer or his authorized assistant, shall not perform his work in a proper and skillful manner, or shall be disrespectful, intemperate, disorderly or otherwise objectionable shall at the written request of the Engineer, be forthwith discharged by the Contractor or Sub-contractor employing such foreman or workmen, and shall not be employed again on any portion of the work provided for by these plans and specifications without the written consent of the Engineer. The Contractor shall employ such force as will, in the opinion of the Engineer, be necessary to complete the work within the contract time.

55. **Equipment.** The plant and equipment owned or controlled by the Contractor shall be of sufficient size to meet the requirements of the work. Except upon the written permission of the Engineer, there will not be allowed any changes in the plant or equipment employed on the work which shall have the effect of decreasing its capacity below that of the plant or equipment named in article 14 of the "Proposal."

56. **Instructions to Foremen.** When the Contractor himself is not present he shall have at all times an authorized representative in charge of the work who shall execute the instructions of the Engineer.

57. **Laws and Ordinances.** The Contractor and his force shall conduct the work in such manner as to fulfill all requirements of Federal, State, County or Municipal laws and ordinances applying to the work in hand, and he shall take such necessary precautions as will guard against accident and loss of life.

58. **Sanitary Provisions.** The Contractor shall provide and maintain in a sanitary condition such accommodations for the use of his employees as may be necessary to comply with the requirements of the State and Local Boards of Health. Public nuisances will not be permitted.

59. **Traffic Regulations.** The work shall be prosecuted in such a manner as to insure the least obstruction to traffic. The convenience of the general public and of the residents along the highway shall be provided for as far as possible. Temporary approaches and crossings of intersecting highways shall be provided and kept in a safe condition.

60. The Contractor shall construct, maintain and finally remove to the satisfaction of the Engineer, all barricades necessary to protect the road while under construction. The contractor shall also provide, place, maintain and finally remove such traffic detour signs as may be necessary to direct public travel properly.

61. Highways closed to traffic shall be protected by effective barricades bearing suitable signs which shall read "Street Closed to Traffic," or "Road Closed to Traffic." All signs shall be illuminated at night.

62. **Contractor's Liability.** The Contractor shall assume all risk and liability for accidents and damages that may accrue to persons or property during the prosecution of the work by reason of negligence or carelessness of himself, his agents or employees, and shall assume also all direct or indirect damages that may be suffered or claimed on account of any such construction or improvement during the time thereof and until the highway is accepted. He shall further assume all responsibility for damages that may arise directly or indirectly from floods, fires, winds, earth or rock slides or other causes until the time the work is formally accepted.

63. There is assumed by the Contractor also the risk and liability for all inconvenience, delay and expense that may be occasioned him in any way by public utilities or other property within the limits of the proposed highway improvement; such as railways, communication and transmission lines and pipes, signs, pipe lines, conduits, drains, sewers, etc.

64. **Opening to Traffic.** The work shall not be opened to traffic until authorized by the Engineer.

65. Should the Contractor open the road to traffic prior to final acceptance without the consent of the Engineer or use the road himself without said consent, he shall be held responsible for any section or portion of roadway so opened or used.

66. Immediately upon the satisfactory completion of a section of pavement from two to three miles in length and upon written acceptance of same by the Engineer, the Contractor shall be relieved of further obligation with respect to said section. It is understood, however, that such approval does not relieve the contractor from responsibility for removing any obstructions or repairing any damages caused by him subsequent to such approval and previous to final acceptance.

67. **Drainage Openings.** The Contractor shall preserve all surface openings or outlets for passage of water and shall restore the same at his own expense should they become filled or clogged due to prosecution of the work.

68. **Tests of Samples of Materials.** All tests of material samples shall be made by the County Superintendent of Highways at 325 County Court House, Chicago, Ill., or at such other place as may be designated, in accordance with the approved methods as described and designated in the specifications.

69. **Preliminary Samples.** Before placing orders for the shipment of materials, the Contractor shall furnish to the County Superintendent of Highways, samples of the materials which he proposes to use. These samples shall be delivered, transportation prepaid, at least ten (10) days and preferably thirty (30) days before ordering shipment of the materials. All samples shall be plainly labeled with the name of the Contractor, the name of the person or company furnishing each material, road, section and route on which this material is to be used.

70 **Inspection During Construction** As the work progresses, samples of the materials may be taken by Inspectors of the County Highway Deparment and these Inspectors shall at all times have access for inspection to all branches of the work The Contractor shall furnish from time to time such samples of the materials as may be requested by these Inspectors, and when deemed necessary by the Engineer, the Contractor shall store separately, and in such a manner as to admit of identification, any or all materials which he proposes to use in this work.

71. **Quality of Materials.** The approval of preliminary samples shall not be considered as a guarantee of acceptance of all materials from the same source, and it shall be understood that all materials delivered on the work and which do not meet the requirements of these specifications may be rejected by the Engineer.

72. **Storage of Materials.** The Contractor shall at his own expense provide suitable buildings or enclosures for the storage of all materials subject to deterioration due to any action of the weather. The expense of storing such materials, including all the necessary handling, shall be borne by the Contractor.

73. **Disposition of Old Material.** All materials and structures including old bridges found on the work and not specified to be used to complete the new construction shall be disposed of by the Contractor as directed by the Engineer. All old bridges shall be removed by the Contractor unless otherwise shown on the plans.

74. The right-of-way of the road, all drainage features and the adjacent premises shall be cleaned of all rubbish or other refuse and left unobstructed. Materials from old structures which may have been removed shall be piled neatly by the roadside as directed by the Engineer.

75. **Lines and Grades.** During construction the Engineer shall furnish the Contractor with the necessary lines, grades and measurements. The care of stakes and markings shall be a duty of the Contractor and he shall replace the lost ones.

76. **Construction Stakes.** At the time and place designated by the Engineer, the Contractor shall furnish all construction stakes, the quantity and quality of which shall meet with the approval of the Engineer. If the Contractor fails to furnish the required stakes at the specified time and place and fails to notify the Engineer of

same, the Engineer may order and have delivered the required stakes and the Contractor shall pay all expenses connected therewith. Upon the request of the Engineer, the Contractor shall furnish him with such assistance as may be necessary for the purpose of driving the stakes and for the necessary measuring in connection therewith. In the event that the Contractor's men have not yet arrived at the time that the stakes should be driven, the Engineer shall arrange to employ the necessary assistance and to purchase the necessary stakes, and the cost for same shall be deducted from the amount due the Contractor.

77. It is understood that all expense in connection with the purchase and delivery of stakes and all labor expense necessary for driving the stakes and measuring for same has been taken into consideration in the proposal and included in the price bid, and consequently no additional payment shall be made the Contractor therefor.

78. All lines, grades and dimensions shall be as indicated on the plans.

79. **Cross Section of Roadway.** The paved portion of the road, together with the shoulders and ditches, shall be constructed to the alignment, grade and cross sections furnished and approved by the County Superintendent of Highways.

80. The paved portion of the road when completed shall be of the width and thickness shown on the plans or as provided for in these specifications and shall be constructed in the manner specified.

81. **Duties of Inspector.** It shall be the duty of the Inspector to see that the provisions of the contract and specifications are fulfilled by the Contractor; and in case all the requirements of the specifications are not fulfilled to report the same to the Engineer. Any instructions which the Inspector may give the Contractor shall in no wise be construed as releasing the Contractor from the proper fulfillment of the terms of this contract as determined by the Engineer. The Inspector shall perform such other duties as the Engineer may indicate.

82. **Engineer as Referee.** It is agreed by both parties to this contract that the Engineer shall act as referee in all questions arising under the terms of this contract between the parties hereto, and that the decision of the Engineer in such cases shall be final and binding upon both alike.

83. **Inspection of Materials and Work.** On all contracts for State Aid road work the Contractor shall permit the Director of Public Works of the State of Illinois, or his authorized representative to inspect the work at any time, and shall, when requested, furnish him with any information he may desire.

84. **Defective Work or Material.** All insufficient, imperfect or damaged work or material when pointed out at any time to the Contractor by the Engineer shall be remedied immediately and made good or removed and replaced to conform to the plans and specifications; and any omission by the Engineer to disapprove or reject any such defective work or material during construction shall not be deemed an acceptance of such work or material, nor shall such omission on the part of the Engineer be construed as in any way releasing the Contractor from remedying, replacing, or making good any defective work or material so as to conform to the plans and specifications. Any work done or materials used without suitable supervision or inspection by a representative of the County Superintendent of Highways may be ordered removed and replaced at the Contractor's expense.

85. **Penalty for Failure to Remove and Renew Defective Work.** Should the Contractor fail to remove and renew any defective work within the time specified in writing by the Engineer, such work may be removed and renewed at the Contractor's expense. Any expense incurred by the County in making these repairs, removals or renewals, shall be paid out of the moneys due or which may become due to the Contractor, or may be charged against the surety bond.

86. **Failure to Complete Work.** It is understood and agreed; that if the Contractor shall fail to complete the work by the date named in the Proposal, the Board of County Commissioners may withhold from such sums as may be due the Contractor, under the terms of this contract, an amount equal to Ten Dollars ($10.00) per day, for every day beyond the time so agreed necessary for the completion of such work, as liquidated damages, for failure to complete said work by the time herein agreed. It is further understood and agreed that the Board of County Commissioners may in any event permanently withhold from the Contractor the amount of engineering cost incurred after the date of completion fixed herein.

87. **Annulment of Contract.** For the failure or neglect of the Contractor to begin said work within the time agreed after the date of notice to begin work, or for failure or neglect to prosecute the same diligently in such a manner as in the opinion of the Engineer is necessary for completion within the time specified, or for failure or neglect of the Contractor to keep and perform any of the agreements in this contract specified to be kept and performed by him; the Board of County Commissioners may, at its option, declare this contract forfeited, and end and terminate all the rights of the Contractor thereunder. It is understood that after the contract has been so declared forfeited by the Board of County Commissioners said Board of County Commissioners may proceed to complete the work, and it is further understood that any excess cost for such completion of the work over the original contract price shall be charged to and paid for by the Contractor or his Surety Company.

88. **Measurement of Quantities.** All quantities shall be measured as indicated in the proposal submitted, and payment shall be made according to the unit prices there listed.

89. **Payments.** It is understood by the Contractor that the compensation as provided in the contract is accepted as full payment for furnishing of materials, labor, tools and equipment and for performing the work contemplated and embraced under the contract; also, for all loss or damages arising out of the nature of the work or from the action of the elements, or from any unforseen difficulties or obstructions which may arise or be encountered during the prosecution of the work, and for all risks of every description connected with the prosecution of the work; also for any expense incurred by or in consequence of the suspension or discontinuance of said work as herein specified, or for any infringement of patent, trade mark or copyright.

90. The payment of any partial or final estimate shall in no way constitute an acknowledgment of the acceptance of the work, and such payment shall not prevent the Board of County Commissioners from investigating and correcting any errors in payment, or from causing any defective work or materials to be removed and replaced or renewed.

91. **Monthly Estimates.** Not oftener than once each month an estimate shall be authorized by the Engineer, provided the amount due on this estimate is at least Five Hundred Dollars ($500.00). The Contractor shall be paid ninety (90) per cent of said estimate by the Board of County Commissioners and the remaining ten (10) per cent shall be reserved until final completion and acceptance of the work.

92. **Payment for Materials.** The Board of County Commissioners may in its discretion pay for any or all materials purchased and delivered for use in the work and said materials when so paid for by the Board of County Commissioners shall become the property of the County and in the event of default on the part of the Contractor the Board of County Commissioners may use or cause to be used such materials in the construction of the work provided to be done in the contract. The amount thus paid by the Board shall go to reduce estimates due the Contractor as the material is used in the work.

93. **Final Acceptance.** Upon completion of a road, or section thereof, constructed or improved under a contract let as provided by law, the Engineer together with a representative of the State Department of Public Works and Buildings shall inspect the same and if completed as provided in the contract, he shall thereupon so report to the Board of County Commissioners. If the Board of County Commissioners approves, it shall notify the Contractor and the road, or section thereof, shall be deemed to have been accepted by the County of Cook.

94. **Final Payment.** When such acceptance shall have been made, then all the money due the Contractor under this contract shall be paid, except, however, that no final payment will be made on account of such construction or improvement until it is shown that all sums of money due for any labor, material, apparatus, fixtures or machinery furnished for the purpose of such improvement have been paid or that the person or persons to whom the same respectively may be due have consented to the final payment to such Contactor.

EXCAVATION AND EMBANKMENT

DESCRIPTION OF EXCAVATION

95. **General.** Excavation shall include the removal and satisfactory disposal of all materials taken from within the limits of the work contracted for, necessary for the preparation and construction of the roadbed, embankments, subgrades, berms, slopes, side ditches, trenches, waterways, approaches, intersecting roads, private entrances, etc. It shall also include all necessary clearing and grubbing (unless separately estimated and indicated in the "Proposal"), the grading and compacting the surface of the roadway and berm as specified and the cleaning and sloping of side ditches, to the required grade and lines shown on the plans.

96. **Drainage Structures.** This classification does not include excavation for bridges, culverts and other structures, and back-filling same up to the natural surface of the ground.

97 **Side Roads and Private Entrances.** There shall be included under excavation also the grading and sloping of all intersecting roads and private entrances to meet the finished grade of the road and all cleaning and sloping of the side ditches of such intersecting roads and private entrances as may be necessary to secure proper drainage.

98. Unless otherwise provided, intersecting roads shall be sloped back on a grade not to exceed five (5) per cent and with a width and cross-section similar to that of the proposed improvement.

99. Private entrances to residences fields, cemeteries, etc., shall be sloped back on a grade not to exceed ten (10) per cent, and with an effective width of roadway of ten (10) feet for field entrances and sixteen (16) feet for all other entrances. The side slopes shall be one and one-half (1½) feet horizontal to one (1) foot vertical for both cuts and fills. Where the required grade carries the work into private property, permission to do such work shall first be obtained by the Contractor from the property owner or an authorized representative.

CLEARING AND GRUBBING

100. **In Excavation.** The surface of the ground within the limits of the right-of-way and throughout the length of the proposed improvement shall be cleared of all trees, brush, logs and other perishable matter, subject, however, to such exceptions as may be made by the Engineer. All the product of clearing and grubbing shall be burned or otherwise removed from the ground as the Engineer may direct, and without damage to adjacent property. In cuts, stumps and roots between slope stakes shall be removed to a depth of at least one (1) foot below the finished earth surface. Stumps beyond the limits of the slope shall be cut off even with the ground.

101. **In Embankment.** All stumps, roots, etc., between slope stakes shall be grubbed out to a depth of at least one (1) foot below the original ground surface. All stumps, posts, etc., outside the limits of the slope shall be cut off even with the ground.

REMOVAL OF STRUCTURES.

102. **General.** All fences, buildings, old bridges and structures of any character not necessary to the construction of the roadway, or other encumbrances upon or within the limits of the roadway shall be removed carefully by the Contractor and the materials so removed shall be piled on the abutting property, neatly and in an acceptable manner, or otherwise disposed of as required.

ROADWAY EXCAVATION

103. **Earth Excavation.** The roadbed and ditches shall be shaped by either cutting or filling as the plans may show. All soft and unsuitable material shall be removed to a depth not to exceed two (2) feet as determined by the Engineer and replaced with suitable material to bring it to the required grade shown on the plans. All suitable material removed from excavation shall be used as far as practicable in the formation of embankment, subgrade, shoulders, etc.

104. Earth excavation shall include the removal of all materials not hereinafter provided for as rock excavation.

105. During the construction of the roadway, the subgrade or roadbed shall be formed and maintained in such a manner that surface water will readily flow to the side ditches.

106. **Rock Excavation.** Rock comprises detached boulders of at least one-half (½) cubic yard each, and material in place in compact beds or masses which in the opinion of the Engineer requires continuous drilling and blasting for economical removal.

107. When during excavation, material is encountered of such a character as to appear to the Contractor that it shall come within the provisions of this specification, the Contractor shall call the Engineer's attention to this material in writing, and shall afford ample opportunity for him to make such measurements as will be necessary to ascertain the volume of the material in question.

108. Within the limits of the metaled way, the rock excavation shall at all points extend at least to the subgrade elevation shown on the plans, and if rock below this elevation is removed, the space shall be back-filled with stone, gravel or slag that will pass through a four-inch ring. The Contractor shall make provision for any special drainage of the subgrade which may be ordered by the Engineer and payment for said provision shall be made in accordance with the terms provided under "extra work," article 46.

109. Provision shall be made over the entire area of the subgrade in the rock cut to the effect that the concrete shall not become separated by reason of the interstices in the stone, gravel or slag subgrade. These interstices may be filled with gravel, graded stone chips and screenings, or otherwise as the Engineer may direct.

110. The completed surface upon which is to be placed the pavement shall conform in cross-section, alignment and general contour to the requirements of the plans with a permissible variation of not to exceed one-half (½) inch either way.

111. Without the limits of the area to be covered by the pavement, the roadway formed by rock excavation shall conform, with a permissible variation either way of two (2) inches, to the requirements of the plans. It shall be free from all projecting points and also fissures, crevices, etc., greater than two inches in width. Should it prove impracticable to excavate the rock in conformity with this requirement, then the rock excavation shall be carried below the established grade and the space back-filled with loose rock or gravel that will pass through a four (4) inch ring. The completed surface shall be uniformly smooth and provide a satisfactory driveway.

EXCAVATION FOR STRUCTURES.

112. **General.** Excavation for bridges, culverts and other structures shall be made to the depth and dimensions shown on the plans.

113. **Back Fill.** Back fill on both sides of all walls shall be kept practically at the same elevation, as the fill is brought up. The back fill in all cases shall be carried up to the natural surface of the ground, as the same existed before any excavation was made by the Contractor.

114. **Stream Channels.** At all drainage structures of span less than sixty (60) feet, measured at right angles to the faces of the abutments or side walls, the stream channel within the limits of the right-of-way and also the adjacent ditches shall be cleared and graded to meet the requirements of the Engineer.

115. **Compensation.** The Contractor shall be allowed no extra compensation for excavation for structures, for backfilling same up to the natural surface of the ground, for spandrel fill on arch bridges, and for clearing and grading the stream channel, it being understood that the prices stated in the Proposal for concrete masonry cover all compensation to be received by the Contractor for such work.

EMBANKMENT.

116. **Methods of Placing.** If filling is necessary, the material shall be placed in layers not to exceed eighteen (18) inches in thickness, and each layer shall form a practically level surface. Where fills are to be made upon existing embankments, the entire surface of these embankments shall be loosened up to a depth of at least six (6) inches. If sufficient material for filling is not obtained from the sections of the road where material must be removed, additional fill material shall be secured from borrow pits. Embankments shall be constructed in successive layers, the first of which shall extend entirely across from the toe of the slope on one side to the toe of the slope on the other side; and successive layers shall extend entirely across from slope to slope until the full amount of material to complete the embankments to the required width and elevation has been placed before any portion of the pavement is built. Filling material may be deposited in layers exceeding eighteen (18) inches but not exceeding three (3) feet in thickness only when specified under "Special Provisions" or shown on the plans. The quantities of "Excavation" and "Borrow" listed in the Proposal include sufficient surplus material to build embankments to such elevation and width that after shrinkage they will conform to the plans. The Contractor shall therefore build all enbankments to the elevations and widths indicated by the Engineer.

117. Only material of a sound and imperishable character shall be used in the embankments, all vegetable matter and general refuse being prohibited.

DISPOSAL OF SURPLUS MATERIAL.

118. **General.** If an excess of material is obtained from excavation, it shall be used in widening the roadway or embankments or deposited on the right-of-way in spoil banks where shown on the plans, or as directed by the Engineer. Where station to station balances are shown on the plans no overhaul will be allowed.

BORROW EXCAVATION.

119. **Description.** When the amount of material required for embankment exceeds the amount of excavation within the limits of the work contracted for, sufficient suitable material for embankment shall be secured from borrow pits located beyond the limits of the work. Borrow shall include the removal and satisfactory placing of the necessary material in the embankment, subgrade, shoulders, etc.

120. **Borrow Pits.** Borrow pits shall either be located on the plans or arranged for by the County Superintendent of Highways. In all cases the right-of-way for such borrow pits shall be secured by the Superintendent of Highways free of cost to the Contractor.

121. Where borrow pits are not shown on the plans and the average haul from such pits exceeds five hundred (500) feet, the Contractor shall be paid an additional sum of one and one-half (1½) cents per cubic yard for each one hundred foot station of haul in excess of the five hundred (500) feet mentioned.

122. Where it is necessary that a fence be removed in order to afford access to the proposed pit or bank, such removal shall be made by the Contractor and shall, upon the completion of the pit or bank be replaced in as good condition as it was originally. While work in connection with the pit or bank is in progress, such fencing shall be provided as will afford protection equal to that which existed prior to the commencement of work. Such fencing shall prevent the passage of cattle, stock, etc., either from the highway to the pit or bank, or vice versa.

123. The side slopes of both borrow pits and spoil banks shall not be steeper than one and one-half (1½) feet horizontal to one (1) foot vertical, and the right-of-way line shall not be closer than two (2) feet to the top of the slope of borrow pits or the foot of the slope of spoil banks. The Contractor shall make suitable provision for the permanent drainage of the borrow pits.

124. The depth of the work throughout the areas of both borrow pits and spoil banks shall be uniform, or where this is impracticable, it shall be such as will conform with the general contour of the adjacent land. Both borrow pits and spoil banks shall be left by the Contractor in a neat and presentable condition to meet the requirements of the Engineer.

SUBGRADE.

125. **Description.** The subgrade will be considered as that portion of the highway upon which the pavement is to be placed. The subgrade shall consist of the natural earth or the excavated material which has been brought to the proper elevation and cross-section and rolled until firm and smooth.

126. **Construction of Subgrade.** The subgrade shall be constructed so that it shall be as nearly as possible of uniform density throughout its entire width. Wherever the roadway extends beyond the lateral limits of the old traveled way, the Contractor shall loosen the compacted portion of this traveled way to a depth of at least six (6) inches and then re-shape and re-roll so as to bring all material within the limits of the subgrade to the same density.

127. The subgrade shall be brought to a true shape, and, after rolling, shall be tested, and if not at the proper elevation at all points, material shall be removed or added, as the case may be, to bring all portions of the subgrade to the correct elevation. All soft and yielding spots shall be removed to a depth not to exceed two (2) feet and all vegetable substance or unsuitable material shall be removed and the space resulting refilled with approved material. The subgrade shall be again rolled until no depressions appear. The rough grading shall be done in such manner that there shall not be left on the subgrade at any time berms of earth or other material that will interfere with the immediate drainage of water from the subgrade or surface to the side ditches. All side ditches shall be kept open during construction.

128. Should the old roadbed consist of gravel or macadam and the pavement extend without the lateral limits of the same, the Contractor shall loosen the old gravel or macadam and then re-roll so as to bring the portion of the subgrade without the lateral limits of the old gravel or macadam roadway to the same density as the portion under the old roadway.

129. The rolling and thorough compaction of the subgrade shall extend for a width of at least twelve (12) inches beyond the edges of the proposed base course or pavement and no back fill of any material excepting concrete will be permitted without re-rolling.

130. Immediately before any concrete is placed upon the subgrade it shall be tested for elevation by the use of a templet, furnished by the Contractor, riding on the side forms behind the mixer. On those areas of the subgrade found to be too high, additional excavation shall be made until the required depth is reached and the excavated material shall be deposited on the shoulders. Those areas below the true elevation shall be filled with concrete making an integral part of the slab proper, all expense for this extra concrete including both labor and material being borne by the Contractor.

131. The subgrade shall be clear of materials that may have fallen upon it and it shall be thoroughly wetted at a time not exceeding twelve (12) hours and as near said time as possible, before the concrete is placed. This wetting shall not be carried on to the extent of forming mud or pools of water.

SHOULDERS.

132. **Earth Shoulders and Ditches.** The earth shoulders shall be shaped and built to such an elevation that after settlement they will conform to the cross section shown on the plan. The cross slope of the earth side roads and ditches shall also be shown as on the plans.

133. Material containing weeds, roots or other vegetable matter shall not be used for shoulders.

METHOD OF DETERMINING GRADING QUANTITIES.

134. **Earth Excavation.** Excavation in earth shall be measured in the original position by the average end area method.

135. **Borrow.** Where borrow in earth is required the fact shall be shown on the plans and the basis for payment shall be the estimated quantities in excavation required to make the fill.

136. **Rock Excavation.** Measurements of excavation in rock shall be by the average end area method. For determining the end areas, measurements shall be taken as follows: Vertical measurements shall extend from the surface of the rock to an elevation six (6) inches below the established grade (or subgrade, if there is one) as shown on the plans, or only to the bottom of the rock where it does not extend down to the established grade or subgrade; horizontal measurements shall extend six (6) inches beyond the slope lines fixed by the Engineer for the work and to which the excavation is made. Payment shall not be made for excavation beyond these boundaries, nor shall deductions be made for the portion that may not be removed.

137. All matters relating to the classification and measurement of excavation materials shall be determined by the Engineer and his decision shall be final and binding equally upon both parties.

TYPE AND WEIGHT OF ROLLER.

138. Wherever it is provided that rolling shall be done on the subgrade for the pavement proper, there shall be used a self-propelling roller weighing at least three (3) tons.

BASIS OF PAYMENT.

139. **Earth Excavation.** This work shall be paid for at the contract unit price per cubic yard for "Excavation in Earth," which price shall include all equipment, tools, labor and work incidental thereto.

140 **Borrow.** This work shall be paid for at the contract unit price per cubic yard for "Borrow in Earth," which price shall include all equipment, tools, labor and work incidental thereto.

141. **Rock Excavation.** This work shall be paid for at the contract unit price per cubic yard for "Excavation in Rock," which price shall include all equipment, tools, labor and work incidental thereto.

BITUMINOUS CONCRETE PAVEMENT

CEMENT-CONCRETE BASE COURSE

DESCRIPTION.

142. The concrete base course shall be constructed on the sub-grade which has been prepared as described in articles 125 to 131 and shall consist of a Portland cement concrete foundation for a pavement.

CEMENT.

143. **General.** The cement shall be some standard brand of Portland cement which has been in practical use in public works and has given satisfactory results therein. No brand of cement shall be used which the Engineer deems unfit for the work.

144. **Brand.** The Contractor shall notify the Engineer in writing as to what brand or brands he intends to use, and before ordering the cement shall receive the written approval of the Engineer as to the brand selected. It is understood that such approval merely covers the selection of the brand, and that the cement itself may be rejected if it fails to meet the requirements specified in A. S. T. M. Standards, 1918, Serial Designation C9-17.

145. **Methods of Sampling and Testing.** No cement shall be used until it has been found satisfactory when sampled and tested according to the methods described in articles 162 and 175.

146. **Storage.** The Contractor shall provide suitable means for storing and protecting the cement against dampness. No cement shall be used which has become caked.

147. **Bulk Cement.** The use of bulk cement will be permitted. The amount of cement for each batch shall be weighed or measured accurately. Before being weighed or measured the cement shall be screened through a screen having 1½ inch square or circular openings to remove lumps. The cement shall be kept in a weather proof compartment separate from the other aggregates until the materials are dumped into the mixer.

FINE AGGREGATES.

148. **General.** The fine aggregate shall consist of clean, hard, durable, uncoated particles of sand preferably of siliceous nature, free from lumps of clay and organic matter. Where approved by the Engineer, a combination of washed or dustless screenings and sand, containing not more than fifty (50) per cent by volume of screenings may be used for the fine aggregate.

149. **Washed or Dustless Screenings.** The washed or dustless screenings used as fine aggregate shall consist of material obtained by crushing hard, durable rock or gravel and shall be free from lumps of clay or of crusts of hardened material at the time of use. If the screenings are produced from rock, the rock shall show a French coefficient of wear of not less than 6.

150. **Impurities.** Fine aggregates containing appreciable quantities of mica, shale, slate, ochre or other soft grains shall not be used. It shall not contain over three (3) per cent by weight of organic matter and clay combined, nor to exceed one-half of one per cent by weight of organic matter. In no case shall fine aggregate containing lumps of frozen material be used.

151. **Grading.** The fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory screens and sieves shall meet the following requirements:

Passing ¼ inch screen	not less than 95%
Passing 20 mesh sieve	30% to 75%
Passing 50 inch sieve	not more than 20%
Passing 100 mesh sieve	not more than 5%

152. **Mortar Strength Test.** When the fine aggregate is mixed with Portland cement in the proportion of one (1) part of cement to three (3) parts of fine aggregate by weight, according to standard methods of making 1 to 3 mortar briquettes, the resulting mortar at the ages of seven (7) and twenty-eight (28) days shall have a tensile strength of at least one hundred (100) per cent of that developed in the same time by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

153. **Methods of Sampling and Testing.** The fine aggregate shall be sampled and tested in accordance with the methods described in articles 163 to 166 and 176, and 178 to 180, inclusive.

COARSE AGGREGATE.

154. **General.** The coarse aggregate shall consist of particles of clean, hard, tough, durable rock in the form of either gravel or crushed material. It shall contain no shale, slate, coal, ochre or other materials which easily disintegrate. It shall be free from vegetable or other deleterious matter, and shall contain no soft, thin or elongated pieces. In no case shall coarse aggregate containing lumps of frozen or partly cemented material be used.

155. **Crushed Stone.** When crushed stone is used, it shall be obtained from rock of fairly uniform quality, having a French coefficient of wear of not less than 6.

156. **Gravel.** Gravel used for coarse aggregate shall show high resistance to abrasion, and no gravel which in the opinion of the Engineer does not show wearing qualities at least equal to crushed stone having a French coefficient of wear of 6 shall be used.

157. **Grading.** All coarse aggregate shall be well graded, and when tested by means of laboratory screens, shall meet the following requirements:

Passing 2½ inch screen	100%
Passing 2 inch screen	not less than 95%
Passing 1 inch screen	30% to 75%
Passing ¼ inch screen	not more than 5%

159. **Methods of Sampling and Testing.** The coarse aggregate shall be sampled and tested in accordance with the methods described in articles 167 to 172 and 176 to 177, inclusive.

UNSCREENED MATERIAL.

160. The use of pit run gravel or of a material made up of a mixture of the fine and coarse aggregates described above will not be permitted.

WATER.

161. The water used in mixing the Portland cement concrete shall be clean, free from oil and organic matter, and when tested with litmus shall show no acid or alkaline reaction.

METHODS OF SAMPLING AND SIZE OF SAMPLES.

162. **Cement.** In general and whenever possible, cement shall be sampled from loaded cars. Samples of at least six (6) oz. shall be taken from every tenth barrel and kept in separate containers. All individual samples from each car or from each lot of approximately two hundred (200) barrels shall be shipped together in a tight box, properly packed and containing a card with full information relative to the sample (including also car number and initials, number on car seals, and number of barrels in the car).

163. **Sand.** Preliminary samples of sand shall be taken either from cars or at the source of supply, from pits, storage piles, etc. During construction the samples shall be taken from cars and all samples shall be selected so as to represent as nearly as possible the average material available.

164. Each sample shall weigh at least ten (10) pounds and shall be shipped in a tight box or tight sack. No sand shall be shipped in loose sacks which will allow the loss of any fine material. All samples shall be properly labeled and each one shall contain a card giving full information relative to the sample.

165. **Screenings.** Where screenings are to be used for fine aggregate, the rock from which the screenings are obtained shall be sampled for quality as described in article 168.

166. The screenings shall be examined also for size, and samples taken either at the plant or from cars. Each sample of screenings shall weigh at least ten (10) pounds and shall be shipped in a tight box or a tight bag, properly labeled and containing a card with full information relative to the sample.

167. **Crushed Stone.** Crushed stone shall be sampled for quality and for size.

168. A sample used to determine the quality of the rock shall be taken either from the quarry or from loaded cars, and shall be representative of the material which it is proposed to use. It shall weigh at least twenty-five (25) pounds and shall consist of pieces of rock at least one and one-half (1½) inches in size, and of one (1) piece at east-three by four by six (3x4x6) inches, free from seams and cracks.

169. Samples used to determine the size of the stone shall be taken, either at the crushing plant or from cars, and shall be selected to represent as nearly as possible the average material available. Each sample shall weigh not less than twenty-five (25) pounds.

170. The samples shall be shipped in tight boxes or bags properly labeled and each one containing a card giving full information relative to the sample.

171. **Gravel.** Samples of the screened gravel shall be taken either at the screening plant or from loaded cars, and shall be selected so as to represent as nearly as possible the average material available.

172. Each sample shall weigh not less than twenty-five (25) pounds. It shall be shipped in a tight box or bag properly labeled and containing a card giving full information relative to the sample.

173. **Water.** When so requested by the Engineer, a sample of the water to be used in the concrete base shall be submitted for inspection. The sample shall consist of at least one (1) quart of water shipped in a clean bottle. This bottle shall be packed carefully and forwarded to the County Superintendent of Highways in a box properly labeled and containing a card giving full information relative to the sample.

174. **Concrete.** Samples of the concrete shall be taken from the work whenever requested by the Engineer. The samples of concrete shall consist of specimens molded by representatives of the Superintendent of Highways, and prepared from the regular run of batches of concrete being turned out. These specimens shall be stored as directed by the Engineer and shall be shipped in a strong box, carefully packed so as to prevent any damage to the samples during shipment. This box shall contain a card giving full information relative to the sample (including also materials used, date of molding, method of storing and date of shipment).

METHODS OF TESTING.

175. **Cement.** All cement shall be tested in accordance with the methods described in A. S. T. M. Standards 1918, Serial Designation C9-17, except that the tests may be performed on the individual samples taken, or on a composite sample from each car, at the option of the Engineer.

176. **Crushed Stone and Screenings.** The abrasion test (French coefficient of wear) shall be made in accordance with U. S. Department of Agriculture, Bulletin 347, p. 5.

177. **Size or Grading or Coarse Aggregate.** The sample of coarse aggregate taken for this test shall weigh at least fifty (50) times the weight of the largest size particle present. After drying at 110°C. (230°F.) a chosen weight of the material shall be passed successively through screens of the sizes referred to in the specifications beginning with the screen having the largest openings. The percentage by weight of material passing each screen shall be determined.

178. **Size or Grading of Fine Aggregate.** The sample of fine aggregate taken for this test shall weigh not less than two hundred (200) grams. After drying at 110°C. (230°F.) a chosen weight of the material shall be passed through a one-quarter (¼) inch screen and successively through the sieves referred to in the specifications, beginning with the sieve having the largest openings. The sieves used shall be standard square mesh sieves as specified in A. S. T. M. Standards 1918, Serial Designation D7-18. The percentage by weight of material passing each screen or sieve shall be determined.

179. **Elutriation Test for Sand or Other Fine Aggregate.** A sample of the dried sand weighing not less than two hundred (200) grams and of known weight shall be placed in a suitable jar with cover, and a weight of clear water equal to at least twice the weight of the sand shall be added. The jar shall then be agitated violently for a minute or two and the sand allowed to settle for about twenty (20) seconds. The water containing clay and organic matter in suspension shall then be decanted off in a weighed container. The agitation and decantation shall be repeated with the addition of clear water until it is found that the wash water remains approximately clear. Care shall be taken that no particles of sand are removed with the wash water and any particles of mineral matter which are retained on a 200-mesh sieve shall be returned to the sand used for the elutriation test. The wash water shall then be evaporated off and the residue of clay and organic matter dried at a temperature of about 110°C. (230°F.). The weight of the residue shall be determined and its percentage of the original weight of sand shall be reported as the clay and organic matter in the sand.

180. When this residue is of dark color or it is desired to determine the amount of organic matter in the sand, the residue shall be ground and thoroughly mixed. A 1-gram sample shall then be taken and ignited at dull red heat to constant weight. The loss on ignition shall be determined and calculated in per cent of the weight of sand used. When it is likely that the residue consists in part of limestone dust, the mineral matter after ignition shall be moistened with water saturated with CO_2 and dried at 110°C. (230°F.). If necessary, the moistening with CO_2 water shall be repeated and the mineral matter brought to constant weight at 110°C. (230°F.). The loss on ignition in per cent of the sand used shall be reported as organic matter in the sand. A similar procedure shall be followed with fine aggregate other than sand.

CONSTRUCTION.

181. **Placing Aggregate.** Both fine and coarse aggregate for the concrete may be delivered directly on the subgrade, provided that the subgrade is sufficiently free from dust or mud to keep the materials free from adulteration. No material shall be deposited upon the subgrade until it has been shaped and brought to a true finish.

182. If the aggregates are deposited on the subgrade, the piles of the coarse and the fine shall be kept separate, and the aggregates shall be conveyed to the mixer in units which will insure accurate measurement of the volume of both fine and coarse aggregate.

183. The quantities of aggregates for each batch shall be exactly sufficient to be used with either one or more sacks of cement, but no batch shall be run requiring fractional sacks of cement.

184. Care shall be taken in removing aggregates from the subgrade that no clay nor earth is taken. Stone forks, approved by the Engineer, shall be used in removing the coarse aggregate from the subgrade.

185. **Side Forms.** The side forms for the concrete pavement shall be of steel. They shall be straight and shall be of a width equal to the thickness of the pavement at the edge. Forms having a less width will be permitted only on condition that they are supported in such manner as to secure proper rigidity and so as to retain the concrete from squeezing out under the forms. All forms shall be set with exactness to the required grade and alignment of the pavement and supported in such a position during the entire operation of tamping and finishing that they will not at any time deviate more than one-fourth (¼) inch from a straight edge ten (10) feet in length. The use of bent side forms will not be permitted. The use of intermediate longitudinal forms to support the templet shall not be permitted, except as may be necessary to construct a monolithic curb and gutter section. All steel forms shall be cleaned and oiled after each time they are used.

186. When special permit is given for tamping and finishing the concrete by hand, side forms of wood may be used. All form lumber shall be at least two (2) inches thick, straight and of a width equal to the thickness of the pavement at the edge. Warped or otherwise objectionable planks shall not be used. All forms shall be set with exactness to the required grade and alignment of the pavement and supported in such a position, during the entire operation of tamping and finishing, that they will not at any time deviate more than one-fourth (¼) inch from a straight edge ten (10) feet in length.

187. The Contractor shall provide sufficient forms so that it will not be necessary to remove them within twelve (12) hours after the concrete is placed. Before concrete is deposited against the forms, they shall be clean.

188. **Proportions for Concrete Base.** In accordance with the detailed cross section as shown on the plans, the concrete for the base shall consist by volume of one (1) part cement, two (2) parts of fine aggregate and three and one-half (3½) parts of coarse aggregate. The aggregate shall be placed in the mixer in such a manner as to insure that a uniform amount of each class of aggregate and cement is used in each batch of concrete; and the method of measuring the cement and the aggregate, whether in wheel-barrows or otherwise, shall be approved by the Engineer, one sack of cement to be considered as 0.95 cubic foot, and all measures to be made by volume.

189. **Use of Additional Cement.** With fairly well graded aggregates, one (1) cubic yard of the concrete will require approximately 1.61 barrels of cement. Should the aggregates be so graded that a larger amount of cement than 1.61 barrels per cubic yard of concrete will be required, the Contractor shall provide such additional cement at his expense.

190. **Checking Quantity of Cement Used.** The Engineer shall compare the calculated amount of cement required according to these specifications and accompanying plans with amounts actually used during each day's work as determined by actual count of the number of sacks or batches of cement used each day. If the amount of cement used on any day is less by more than two (2) per cent of the amount hereinbefore required, the Contractor shall be required to remove all such sections and rebuild them according to these specifications, at his expense.

191. **Consistency.** There shall be used such an amount of water that the consistency of all the batches will be uniform and so that the concrete will show a slump not greater than one (1) inch nor less than one-half (½) inch when subjected to the following test: A slump can being in the form of a frustum of a cone having a top diameter of four (4) inches, a base diameter of eight (8) inches and a height of twelve (12) inches shall be placed on its base and filled with concrete which shall be tamped until all voids are filled, and a slight film of mortar appears on the surface. The slump can shall then be removed slowly and the vertical settlement or "slump" of the concrete noted.

192. **Mixing Concrete.** Concrete shall be mixed in a batch mixer of a type approved by the Engineer. No mixer shall be used which requires less than one (1) sack of cement per batch.

193. The mixer shall either be equipped with an attachment for automatically locking the discharge, or it shall be accompanied by a time recording device that will prevent emptying the mixer until all the materials have been mixed together for the minimum time required.

194. The type of mixer shall insure uniform distribution of the materials throughout the mass until the mixture is uniform in color and smooth in appearance. All of the materials, including the water for each batch of concrete, shall be mixed at least one (1) minute while the drum revolves at the speed for which it was designed, but between fourteen (14) and twenty (20) revolutions per minute. If a thorough mixing of the concrete in the opinion of the Engineer is not affected by this process, a sufficient number of additional revolutions at the same rate shall be given it until a thorough mixing of each batch of concrete is secured. Any concrete mixed less than one minute as specified herein shall be dumped outside of the forms and removed from the road at the entire expense of the Contractor. The volume of material mixed per batch shall not exceed the manufacturer's rated capacity of the drum.

195. No material for a batch of concrete shall be placed in the drum of the mixer until all of the previous batch has been discharged therefrom. Water shall be added at the time the materials are being run into the mixer.

196. **Central Mixing Plants.** The use of a central mixing plant and the transportation of mixed concrete to the road will be permitted provided that there is no segregation of the concrete when it arrives at the point where it is to be deposited in the road and provided that the period of time that has elapsed from the time the concrete is mixed until it is deposited in the road does not exceed forty (40) minutes.

197. **Retempering.** Mortar or concrete which has partially set shall not be retempered by mixing the mortar or concrete with additional materials or water.

198. **Concrete Shall Not be Placed During Freezing Weather.** Concrete shall not be mixed or placed when the temperature is below 35°F.

199. All concrete shall be effectively protected from the action of frost for a period of at least five (5) days after it is deposited in the work. All concrete which has not been properly protected as above specified and concrete which may have become damaged by frost shall be replaced at the Contractor's expense upon written notice from the Engineer.

200. Concrete shall not be placed upon a frozen subgrade.

201. **Placing and Finishing Concrete Base Course.** The concrete shall be placed between the side forms at least to the full thickness of the pavement and in successive batches for the entire width. After the concrete has been deposited, it shall be leveled off from one-half (½) to three quarters (¾) of an inch higher than the finished base course by means of a templet independent of the tamping templet and then tamped mechanically with a machine approved by the Engineer, until all voids are removed and the concrete is thoroughly compacted. The mechanical tamper shall go over each area of the pavement at least five (5) times and at such intervals as will give the desired results. The mechanical tamper shall be kept in good repair at all times and shall operate so as to give the entire surface of the pavement repeated blows. The vertical stroke of the tamper shall be at least one (1) inch in length.

202. Hand tamping and finishing will not be permitted except in case of a break down or other emergency and then only upon special permit from the Engineer. In case hand tamping and finishing are used, at least one man per 150 lineal feet of base course laid per day and at no time less than two men shall be engaged at the exclusive work of tamping the concrete. The tamping templet shall have a tamping face of approximately four (4) inches and shall have sufficient rigidity to maintain the true cross section of the road.

203. If there is a surplus of water or an appreciable amount of laitance from the cement on the surface of the concrete base course after tamping, the surface shall be rolled as follows: The roller shall be operated slowly transversely from one edge of the concrete base course to the other and then back again over the same area. A one-half (½) lap shall then be made and the rolling continued as before until the entire surface has been rolled. In moving the roller to make the lap, great care shall be taken not to mar or displace the concrete.

204. The roller shall be of smooth steel approximately twelve (12) inches in diameter, and shall have a total length of six (6) feet. The weight shall not exceed one pound per inch of length of roller. The roller shall be operated by means of ropes.

205. In case the tamping and rolling does not produce a satisfactory surface, the surface shall be belted before the concrete obtains its initial set. This belting shall be of short, rapid, transverse strokes having a sweeping longitudinal motion.

206. The belt shall be of canvas-rubber composition from two (2) to four (4) ply and shall have a width not less than six (6) inches, and a length at least two (2) feet longer than the width of the pavement.

207. The use of a short handled wood float as a substitute for the belt will be permitted only by the written authorization of the Engineer. If such permission is granted, the finishing shall be carried on from a suitable bridge, no part of which shall come in contact with the concrete. The use of a long handled wood float is prohibited.

208. The finished concrete base course shall be uniform in character and appearance and free from voids and depressions and true to the cross sections shown on the plans. Portions of the base course showing voids in the concrete after finishing and removal of the side forms shall be rejected.

209. After the base course has been properly tamped and surfaced, the surface of the base course shall be broomed or otherwise roughened to the satisfaction of the Engineer, to insure a satisfactory bond between the base course and the pavement.

210. **Joints.** At the close of each day's work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete has taken its initial set, a butt construction joint shall be made at right angles to the center line of the pavement.

211. For this joint there shall be used a clean plank having a thickness of not less than two (2) inches, a width not less than the thickness of the pavement and a length not less than the width of the pavement. The plank shall be cut true to the crown of the finished base course and shall be accurately set and held in place in a plane at right angles to the longitudinal surface of the pavement.

212. Upon the resumption of work any surplus concrete remaining upon the subgrade shall be removed. The plank shall then be carefully removed and the fresh concrete deposited against the old in such a manner as to avoid interference with the edge of the old concrete.

213. **Uneven Surface to be Remedied.** Before the concrete has taken its initial set, the surface of the base course shall be tested for irregularities or waves by means of a ten (10) foot straight-edge. Should there appear at a joint or other point on the concrete base course surface any uneveness amounting to one-quarter (¼) of an inch or over, above or below the general contour of the surface of the concrete as determined above, then the Contractor at no expense to the County, shall at once take such means as will be effective to remove such unevenness and produce a true and uniform surface. After the concrete has obtained its final set, no depressions shall be remedied by filling with concrete or other material unless the concrete slab has been cut so as to insure a thickness of at least four (4) inches for the new material and with sides cut vertical. If any such depression requires a patch of this character of over two (2) square feet in extent, then the entire slab of concrete shall be cut through to the foundation for the entire width of the road and new concrete placed so as to produce a true surface.

214. **Protecting and Curing of Concrete Base Course.** After the concrete base course has been finished as above described, it shall be protected from the sun and wind with suitable frames covered with canvas. In case the pavement dries too rapidly, resulting in hair cracks or checking of the surface, the canvas shall be kept wet. As soon as the concrete sets sufficiently, canvas shall be laid directly upon the concrete and the canvas shall be kept wet if, in the opinion of the Engineer, it is necessary in order to protect and cure the base course properly. The canvas shall not be removed until the following day. The surface of the base course shall be saturated with water twice daily for one week upon removing the canvas.

215. **Basis of Payment.** This work together with pavement or wearing course shall be paid for at the contract unit price per square yard for the "Pavement," including both the pavement and the concrete base course complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

BITUMINOUS CONCRETE PAVEMENT

WEARING COURSE

DESCRIPTION.

216. This pavement shall consist of a bituminous concrete wearing course, with or without a binder course, constructed on a base course in accordance with these specifications.

217. Whenever a bidder wishes to submit a proposal for any type of bituminous concrete wearing course, patented or otherwise, other than covered by these specifications, the bid shall be submitted on the standard proposal form, furnished by the Superintendent of Public Service, with the name of the pavement and price per square yard, including both the pavement surface and the concrete base course, inserted in the blank spaces provided under "Prices." The price bid shall include all royalties, copyrights, etc. Such a bid must be accompanied by detailed specifications for such wearing course.

BITUMINOUS MATERIAL.

218. **General Character.** The bituminous material shall comply with the requirements of one of the specifications, Native Asphalts, Oil-Asphalts A, Oil-Asphalts B, or Refined Tar. The specifications to be used in purchasing the bituminous material shall be those indicated in the plans and specifications prepared by the Engineer, and the material which the contractor proposes to use shall also be indicated in the "Proposal."

SPECIFICATIONS NATIVE ASPHALT.

219. **Asphalt for Bituminous Concrete.** The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

220. Specific gravity 25°C./25°C. (77°F./77°F.) .... not less than 1.040

221. Flash point .... not less than 177°C. (350°F.)

222. Penetration at 25°C. (77°F.), 100 gm., 5 sec.:

When total bitumen is more than 80% .... 55 to 75

When total bitumen is less than 80% .... 50 to 70

223. Loss at 163°C. (325°F.), 5 hours .... not over 3.0%

224. Penetration of residue at 25°C. (77°F.), 100 gm., 5 sec.:

When total bitumen is more than 80% .... not less than 30

When total bitumen is less than 80% .... not less than 25

225. Total Bitumen:

Bermudez products .... not less than 95.0%

Cuban products .... not less than 80.0%

Trinidad products .... not less than 65.0%

226. Per cent of total bitumen insoluble in 86°B. naphtha .... 15.0 to 29.0

227. Fixed carbon .... 8.0% to 14.0%

228. **Brittleness Test.** A cylindrical prism of the asphalt one (1) centimeter in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes shall bend 180 degrees at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten (10) seconds.

229. References to the methods of tests to be used in determining the characteristics specified in articles 220 to 227, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

SPECIFICATIONS OIL-ASPHALTS A.

230. **Asphalt for Bituminous Concrete.** The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

231.	Specific gravity 25°C./25°C. (77°F./77°F.)	1.020 to 1.060
232.	Flash point	not less than 177°C. (350°F.)
233.	Ductility at 25°C. (77°F.)	not less than 100 cm.
234.	Penetration at 25°C. (77°F.), 100 gm., 5 sec	55 to 75
235.	Loss at 163°C. (325°F.), 5 hours	not over 2.0%
236.	Penetration of residue at 25°C. (77°F.), 100 gm., 5 sec	not less than 30
237.	Total bitumen	not less than 99.5%
238.	Per cent of total bitumen insoluble in 86°B. naphtha	15.0 to 29.0
239.	Fixed carbon	9.0% to 17.0%

240. **Brittleness Test.** A cylindrical prism of the asphalt one (1) centimeter in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes, shall bend 180 degrees at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten (10) seconds.

241. References to the methods of tests to be used in determining the characteristics specified in articles 231 to 239, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

SPECIFICATIONS OIL-ASPHALTS B.

242. **Asphalt for Bituminous Concrete.** The asphalt shall be homogeneous and free from water. It shall conform to the following requirements:

243.	Specific gravity 25°C./25°C. (77°F./77°F.)	0.995 to 1.045
244.	Melting point	not less than 55°C. (131°F.)
245.	Flash point	not less than 200°C. (392°F.)
246.	Ductility at 25°C. (77°F.)	not less than 15 cm.
247.	Penetration at 25°C. (77°F.), 100 gm., 5 sec	50 to 70
248.	Loss at 163°C. (325°F.), 5 hours	not over 2.0%
249.	Penetration of residue at 25°C. (77°F.), 100 gm., 5 sec	not less than 30
250.	Total bitumen	not less than 99.5%
251.	Per cent of total bitumen insoluble in 86°B. naphtha	20.0 to 28.0
252.	Fixed carbon	8.0% to 15.0%

253. **Brittleness Test.** A cylindrical prism of the asphalt one (1) centimeter in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes, shall bend 180 degrees at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten (10) seconds.

254. References to the methods of tests to be used in determining the characteristics specified in articles 243 to 252, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

SPECIFICATIONS REFINED TAR.

255. **Refined Tar for Bituminous Concrete.** The refined tar shall be homogeneous and free from water. It shall conform to the following requirements:

256.	Specific gravity 25°C./25°C. (77°F./77°F.)	1.200 to 1.270
257.	Float Test at 50°C. (122°F.)	170 sec. to 210 sec.
258.	Total distillate by weight:	
	To 170°C. (338°F.)	not over 0.5%
	To 300°C. (572°F.)	not over 15.0%
	Specific gravity of distillate 25°C./25°C. (77°F./77°)	not less than 1.030
	Melting point of residue	not over 70°C. (158°F.)
259.	Solubility in carbon disulphide	76.0% to 88.0%
260.	Inorganic matter (ash)	not over 0.5%

261. References to the methods of tests to be used in determining the characteristics specified in articles 256 to 260, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

MINERAL FILLER.

262. **General Character and Grading.** The filler shall consist of limestone, silica or other mineral matter meeting the approval of the Engineer. It shall be free from organic or other objectionable material, and when tested by means of laboratory sieves, it shall meet the following requirements:

Passing 40 mesh sieve	100%
Passing 200 mesh sieve	not less than 75%

263. **Methods of Sampling and Testing.** The mineral filler shall be sampled and tested in accordance with the methods described in articles 279, 280 and 303.

FINE AGGREGATE.

264. **General Character.** The fine aggregate other than the filler, passing a 10-mesh sieve, shall consist of clean, hard, durable grains of sand or other material meeting the approval of the Engineer. It shall be free from organic matter, and the grains shall not show any coating of clay or other deleterious matter.

265. **Grading.** It shall be so graded that it can be combined with the mineral filler and coarse aggregate to produce the mineral aggregate required by the bituminous concrete mixture described in article 309.

266. **Methods of Sampling and Testing.** The fine aggregate shall be sampled and tested in accordance with the methods described in articles 281, 282 and 303.

COARSE AGGREGATE.

267. **General Character.** The coarse aggregate for the wearing surface or for the binder coarse shall consist of limestone chips or other crushed material meeting with the approval of the Engineer. It shall be free from thin or elongated pieces, soft or disintegrated material, dirt or other objectionable matter appearing either free or as a coating on the stone.

268. **Physical Properties.** The rock from which the chips are produced shall meet the following requirement:

French coefficient of wear	not less than 6

269. **Grading of Chips for Wearing Course.** The chips for the wearing course shall be from one-half (½) to one-tenth (1-10) of an inch in size, and shall be so graded that they can be combined with mineral filler and fine aggregate to produce the mineral aggregate required by the bituminous concrete mixture described in article 309.

270. **Grading of Chips for Binder Course.** The chips for the binder course shall be from one (1) inch to one-tenth (1-10) of an inch in size and shall be so graded that they can be combined with the fine aggregate to produce the mineral aggregate required by the bituminous binder course mixture described in article 308.

271. **Methods of Sampling and Testing.** The coarse aggregate for the wearing surface or for the binder course shall be sampled and tested in accordance with the methods described in articles 283 to 286, inclusive, 303 and 304.

METHODS OF SAMPLING AND SIZE OF SAMPLES.

272. **Bituminous Material.** In general, samples submitted during construction shall be taken from the material when it is received on the work. Preliminary samples may be taken at the plant, however, and where the amount of work is such as to warrant plant inspection, the samples selected during construction may be taken at the plant sufficiently in advance to allow time for testing before shipment of the material.

273. In general, the bituminous material shall be sampled from the barrels or drums in which the material is shipped. As far as possible, the material from the first two (2) inches near the surface shall not be included, and the sample shall be taken as near the center of the barrel or drum as practicable. Samples shall be taken from not less than three (3) per cent of the barrels or drums, and the several portions of the sample from each carload or lot of approximately two hundred (200) barrels shall be mixed together in a clean container.

274. When the bituminous material is hauled while hot to the work from the plant where it is produced, the material may be sampled from the tanks or distributors by any device which will permit the securing of samples representative of the entire depth of material. Where plant inspection is made the samples may be taken also from drip valves during the pumping of the material. Drip samples shall be taken as soon as the pumping has progressed long enough to clean the line and the drip valve shall be so regulated that the collecting of the material continues through the entire time of pumping.

275. When the bituminous material does not appear to be of uniform quality, several individual samples shall be taken for examination. These individual samples shall be shipped in separate containers. These samples may each represent a single barrel or drum, or a portion of a shipment. Indivudual samples may be taken from hot fluid bituminous materials in tanks by means of thieves. Samples taken from the middle, top and bottom of tanks will usually be sufficient to determine if the material is of uniform quality.

276. All samples, whether composite or individual samples, shall consist of not less than one (1) quart of the bituminous material.

277. All samples shall be shipped in clean tin containers with tight-fitting covers. They shall be properly labeled and each one shall be accompanied by a card, securely attached, giving full information relative to the sample.

278. When asphalt cement to be used in the work is prepared at the bituminous concrete mixing plant from hard asphalt and fluxing material, samples of the asphalt, of the flux, and of the resulting asphalt cement shall be taken for examination.

279. **Mineral Filler.** The sample shall be selected to represent as nearly as possible the average material. In general, the samples of filler shall be taken from material in cars or delivered to the mixing plant.

280. Each sample shall weight not less than two (2) pounds, and shall be shipped in a tight box or tin container properly labeled and containing a card giving full information relative to the sample.

281. **Sand.** Preliminary samples of the sand shall be taken from the deposits, but during construction the samples shall be taken from material delivered to the mixing plant. In general, the samples shall be selected to represent as nearly as possible the average material available. When the sand is not of uniform size or quality, samples may be selected, however, to represent the maximum variations of the material.

282. Each sample shall weigh not less than five (5) pounds. It shall be shipped in a tight box or bag properly labeled and containing a card giving full information relative to the sample.

283. **Stone Chips.** Stone chips shall be sampled for quality and for size.

284. A sample to determine the quality of the rock from which the chips are obtained shall be taken from the quarry, and shall be representative of the material which it is proposed to use. It shall weigh at least twenty-five (25) pounds and shall consist of pieces of rock at least one and one-half (1½) inches in size, and of one (1) piece at least three by four by six (3x4x6) inches, free from seams and cracks.

285. Preliminary samples to be used to determine the size of the chips may be taken at the crushing plant or from cars or storage piles, but during construction the samples shall be taken from materials delivered to the mixing plant.

286. Each sample, whether it represents the average material or only a portion of the shipment, shall weigh not less than ten (10) pounds. It shall be shipped in a tight box or bag, properly labeled, and containing a card giving full information relative to the sample.

287. **Bituminous Concrete Mixtures.** Samples of the bituminous concrete mixtures for the binder course and for the wearing surface shall be taken from the material which is being placed in the pavement or being hauled to the work. In general the samples shall be representative of the average material, but samples may be taken also of any load or lot of the material which does not appear to be of the required quality.

288. Each sample shall weigh not less than three (3) pounds, and shall be shipped in a tight tin container, properly labeled and to which is securely attached a card giving full information relative to the sample.

289. **Pavement.** Samples of the finished bituminous concrete pavement shall consist of pieces at least six (6) inches square cut to the full depth of the surface mixture. When a binder course is used, these samples of the pavement shall be taken to the full depth of the binder course. These samples shall be boxed carefully in order that they are not damaged during shipment. Each sample shall be accompanied by a card giving full information relative to the sample.

METHODS OF TESTING.

290. **Bituminous Material.** The bituminous material shall be tested in accordance with the following methods:

291. Specific gravity. Standardized hydrometers or pycnometers. U. S. Dept. of Agriculture, Bulletin 314, p. 4.

292. Flash point. U. S. Dept. of Agriculture, Bulletin, 314, p. 17 (Open Cup).

293. Ductility. A. S. C. E. 1914 Proc., p. 3047.

294. Penetration. A. S. T. M. Standards, Test D5-18.

295. Float Test. U. S. Dept. of Agriculture, Bul. 314, p. 9.

296. Volatilization. U. S. Dept. of Agriculture, Bul. 314, p. 19, except that 50 gm. sample is used in flat bottom box 2$\frac{3}{16}$ inches in diameter and 1$\frac{3}{8}$ inches in depth (Gill style, 3 oz. deep pattern box).

297. Distillation. A. S. T. M. Standards, Test D20-18.

298. Melting point. A. S. T. M. Tentative Standard D36-16T, Proc. A. S. T. M. 1918, p. 707.

299. Total Bitumen. (Solubility in Carbon Disulphide). U. S. Dept. of Agriculture, Bulletin 314, p. 25.

300. Naphtha Solubility. U. S. Dept. of Agriculture, Bul. 314, p. 28.

301. Fixed Carbon. U. S. Dept. of Agriculture, Bul. 314, p. 30.

302. Inorganic Matter (Ash). U. S. Dept. of Agriculture, Bul. 314, p. 27.

303. **Size or Grading of Filler, Sand and Stone Chips.** The material shall be thoroughly dry at the time of testing, and if necessary, the sample shall be dried at 110°C. (230°F.). The sample of mineral filler taken for this test shall weigh not less than one hundred (100) grams, the sample of sand not less than two hundred (200) grams, and the sample of stone chips not less than five hundred (500) grams. The material shall be passed successively through the sieves referred to in the specifications, beginning with the sieve having the largest openings. All sieves shall be standard square mesh sieves as specified in A. S. T. M. Standards D7-18. The percentage by weight of material passing each sieve and retained on the following sieve shall be determined.

304. **Quality of Stone Chips.** The abrasion test (French coefficient of wear) shall be made in accordance with the method described in U. S. Department of Agriculture, Bulletin 347, p. 5.

305. **Bituminous Concrete Mixture and Bituminous Pavement.** The sample of the bituminous concrete mixture or of the finished bituminous pavement shall be extracted in a standard form of centrifuge or of extractor for bituminous aggregates. (See U. S. Department of Agriculture, Bulletin 314, p. 36.) The fine mineral matter removed with the bitumen shall be determined by ignition of the bituminous material. The mineral remaining after extraction shall be dried and passed successively through the sieves referred to in the specifications as described in article 303.

OPERATION OF MIXING PLANT.

306. **Type of Plant.** The mixing plant shall be of a standard type approved by the Engineer and shall be equipped with necessary heating kettles, driers, screens, bins, scales and mixer.

307. **Method of Mixing.** The mineral aggregate previously mixed and the asphaltic cement shall be heated separately to a temperature of not less than 300°F., nor more than 350°F. When tar is used, the mineral aggregate and the tar shall also be heated separately to a temperature of not less than 250°F., and not more than 300°F. The filler used in the surface mixture shall be mixed while cold with hot mineral aggregate. The asphaltic cement or tar shall then be mixed with the other materials at the required temperature, in the proper proportions, and in a manner such as to produce a thoroughly homogeneous mixture. The proportions of the asphaltic cement or tar and of the filler and mineral aggregate, shall at all times be determined by weight unless a method of gauging, approved by the Engineer, is used.

308. **Mixture for Binder Course.** The mixture for the binder course shall be composed of asphaltic cement or tar, stone chips and fine aggregate. The materials shall be so combined that the mixture shall contain average proportions by weight as follows:

Bitumen	4½% to 6½%
Mineral passing 10 mesh	15 % to 30 %
Mineral passing 2 mesh and retained on 10 mesh	40 % to 70 %
Mineral passing 1 mesh and retained on 2 mesh	10 % to 30 %

309. **Mixture for Wearing Course.** The mixture for the wearing course shall be composed of coarse aggregate, fine aggregate, filler and asphaltic cement or tar. The materials shall be so combined that the mixture shall contain average proportions by weight as follows:

Bitumen	7½% to 9%
Mineral passing 200 mesh	7 % to 10%
Mineral passing 40 mesh and retained on 200 mesh	20 % to 30%
Mineral passing 10 mesh and retained on 40 mesh	25 % to 35%
Mineral passing 4 mesh and retained on 10 mesh	8 % to 22%
Mineral passing 2 mesh and retained on 4 mesh	0 % to 10%
Mineral passing 2 mesh and retained on 10 mesh	18 % to 32%

310. **Control of Mixtures.** Enough samples of the mixtures shall be tested to give the Engineer an accurate knowledge of the composition of the mixtures. In general, at least one sample of the bituminous concrete for the binder course and one sample of the bituminous concrete for the wearing surface shall be taken by the Engineer or his Inspectors for every one thousand (1,000) square yards of pavement. The Contractor shall make such changes in the proportions of the ingredients used, as the results of the analysis of these samples indicate to be necessary in order to meet the requirements of the specifications, and as the Engineer may find necessary in order to obtain the best results with the materials being used.

CONSTRUCTION.

311. **Seasonal and Weather Conditions.** The bituminous concrete mixture shall not be placed at the following times:

(a) When the temperature is below 50°F. in the shade.

(b) When the pavement is damp or in otherwise unsatisfactory condition.

(c) From October 15th to May 1st, except by written permission of the Engineer.

312. **Side Forms.** The edges of the bituminous concrete pavement shall be protected by temporary curbs or side forms of a thickness at least equal to that of the finished pavement and preferably of six (6) to eight (8) inches in width. These forms shall be accurately set to the alignment and grade of the pavement and shall be held securely in place by adequate stakes and bracing. Planks that are warped shall not be used for side forms. When concrete curbs are shown on plans the use of side forms shall be eliminated.

313. **Mixture Hauled to Work.** The mixtures for the binder course and the wearing course shall be hauled to the work in wagons, trucks or other suitable vehicles covered with canvas or similar material. Upon arrival on the work, the mixture shall be dumped at such a distance from the pavement that all the mixture shall be turned and distributed to the place where it is to be raked.

314. **Temperature of Mixture When Spread.** The temperature of the mixtures at the time of spreading shall not be less than 225°F. when tar is used, and not less than 250°F. when asphaltic cement is used.

315. **Placing Binder Course.** The bituminous concrete mixture for the binder course shall not be deposited on the work until the base course is in suitable condition. All dirt and loose material upon the base course shall be removed. The bituminous concrete binder shall then be deposited roughly in place by means of hot shovels and shall be spread evenly over the base by means of hot iron rakes to a depth such that after receiving its ultimate compression by rolling or tamping, the binder course shall have the thickness shown on the plans and its surface shall be parallel to the established grade for the finished pavement.

316. There shall not be laid on any one day more binder than can be covered with the wearing course the same day. Binder when laid shall be followed and covered with the wearing course as soon as practicable in order to effect the most thorough bond between the binder and the wearing course.

317. The binder course shall be kept as clean and as free from traffic as possible under working conditions. If necessary, it shall be swept off immediately before laying the wearing course. Binder shall not be laid during unsuitable weather or climatic conditions, nor upon a base course that is wet or insufficiently cured.

318. **Rolling Binder Course.** Immediately after the bituminous concrete binder has been spread evenly, it shall be rolled until thoroughly compacted and the surface is smooth and free from waves. At all locations inaccessible to the roller, the compression shall be effected with hot iron tampers, weighing not less than twenty-five (25) pounds and having a bearing area not more than fifty (50) square inches. All unevenness or depressions shall be removed before the rolling is completed. The rate of rolling when the roller is in continuous operation shall not exceed three hundred (300) square yards of surface per hour. The roller shall be kept moist, but the use of excessive water on the steam roller to prevent adhesion of the bituminous material will not be permitted. The rolling shall be done while the bituminous aggregate is still hot enough to compact properly.

319. Any material which is rolled after it has cooled to such an extent that the surface presents signs of cracking or checking may be ordered removed from the work by the Engineer. All areas showing an excess of asphaltic cement after compression shall be cut out and the space refilled with other satisfactory binder. All binder that shows lack of bond or that is in any way defective or which may become broken up before it is covered with wearing course shall be taken up and removed from the road, and replaced with approved binder at the expense of the Contractor.

320. **Placing Wearing Course.** When the wearing course is laid directly on the base course, the base course shall have been cleaned as described in articles 315 to 317. When the wearing course is laid on a binder course, the binder course shall be kept as clean and as free from traffic as is possible under working conditions, and any dirt or loose material on the binder course shall be removed before the wearing surface is placed. In either case the vertical surfaces of curbing, iron covers for underground service, headers, etc., in contact with the bituminous wearing surface shall be coated with asphaltic cement or tar. The bituminous concrete mixture shall then be placed as described in articles 315 to 317, and shall be spread to a depth such that after receiving its ultimate compression, the finished pavement shall conform to the established grade. The surface mixture shall be raked slightly high adjacent to curbing, gutters, iron covers for underground service, etc., in order that at such places the surface shall be slightly higher than the established grade, but not to exceed one-fourth (¼) of an inch.

321. **Rolling Wearing Course.** In general, the wearing course shall be rolled as described in articles 318 and 319. A ten (10) foot straight edge laid parallel to the center line of the pavement shall be used in testing the surface for unevennesses or depressions and any variations exceeding one-fourth (¼) of an inch shall be removed. Such portions of the completed pavement as are defective in finish, compression or composition, or that do not comply in all respects with the requirements of the specifications, shall be taken up, removed and replaced with suitable material, properly made and laid in accordance with these specifications at the expense of the Contractor. The rate of rolling when the roller is in continuous operation shall not exceed two hundred (200) square yards of surface per hour.

322. **Type and Weight of Roller.** For all rolling provided in articles 318 to 321 there shall be used a tandem self-propelling roller, weighing not less than two hundred (200) pounds nor more than two hundred and fifty (250) pounds per inch of tread. The initial compression of the wearing course with a light tandem roller weighing from three (3) to six (6) tons will be permitted, provided the final compression is given with a roller weighing not less than two hundred (200) pounds nor more than two hundred and fifty (250) pounds per inch of tread.

323. **Joints.** The paving shall be done continuously so that the number of joints between the hot and cold material may be reduced to the minimum. When a joint is unavoidable, the edge of the cold material shall be trimmed to a rough feather edge, and the surface on which the joint is to be made shall be painted with bituminous cement. The hot bituminous concrete shall then be raked over the feathered edge and thoroughly rolled.

324. **Surface Finish.** As soon as possible after the rolling of the bituminous concrete mixture is completed, and while the surface is still fresh and clean, there shall be swept thereon sufficient Portland cement to give a uniform color to the surface of the pavement.

325. **Basis of Pavement.** This work shall be paid for at the contract unit price per square yard for "Bituminous Concrete Pavement," including both the Bituminous Pavement and the Base Course herein provided, complete in place, which price shall include all materials, equipment, tools and labor work incidental thereto.

PORTLAND CEMENT CONCRETE PAVEMENT.

DESCRIPTION.

326. This pavement shall consist of one course of Portland cement concrete constructed on a prepared subgrade in accordance with these specifications.

CEMENT.

327. **General.** The cement shall be some standard brand of Portland cement which has been in practical use in public works and has given satisfactory results therein. No brand of cement shall be used which the Engineer deems unfit for the work.

328. **Brand.** The Contractor shall notify the Engineer in writing as to what brand or brands he intends to use, and before ordering the cement shall receive the written approval of the Engineer as to the brand selected. It is understood that such approval merely covers the selection of the brand, and that the cement itself may be rejected if it fails to meet the requirements specified in A. S. T. M. Standards 1918, Serial Designation C9-17.

329. **Methods of Sampling and Testing.** No cement shall be used until it has been found satisfactory when sampled and tested according to the methods described in articles 162 and 175.

330. **Storage.** The Contractor shall provide suitable means for storing and protecting the cement against dampness. No cement shall be used which has become caked.

331. **Bulk Cement.** The use of bulk cement will be permitted. The amount of cement for each batch shall be weighed or measured accurately. Before being weighed or measured the cement shall be screened through a screen having 1½ inch square or circular openings to remove lumps. The cement shall be kept in a weather proof compartment separate from the other aggregates until the materials are dumped into the mixer.

FINE AGGREGATE.

332. **General.** The fine aggregate shall consist of clean, hard, durable, uncoated particles of sand preferably of a siliceous nature, free from lumps of clay and organic matter. Where approved by the Engineer, a combination of washed or dustless screenings and sand, containing not more than fifty (50) per cent by volume of screenings may be used for the fine aggregate.

333. **Washed or Dustless Screenings.** The washed or dustless screenings used as fine aggregate shall consist of material obtained by crushing hard, durable rock or gravel and shall be free from lumps of clay or of crusts of hardened material at the time of use. If the screenings are produced from rock, the rock shall show a French coefficient of wear of not less than 6.

334. **Impurities.** Fine aggregate containing appreciable quantities of mica, shale, slate, ochre or other soft grains shall not be used. It shall not contain over three (3) per cent by weight of organic matter and clay combined, nor to exceed one-half of one per cent by weight of organic matter. In no case shall fine aggregate containing lumps of frozen material be used.

335. **Grading** The fine aggregate shall be well graded from coarse to fine and when tested by means of laboratory screens and sieves shall meet the following requirements:

Passing ¼ inch screen	not less than 95%
Passing 20 mesh sieve	30% to 75%
Passing 50 mesh sieve	not more than 20%
Passing 100 mesh sieve	not more than 5%

337. **Mortar Strength Test.** When the fine aggregate is mixed with Portland cement in the proportions of one (1) part of cement to three (3) parts of fine aggregate by weight, according to standard methods of making 1 to 3 mortar briquettes, the resulting mortar at the ages of seven (7) and twenty-eight (28) days shall have a tensile strength of at least 100 per cent of that developed, in the same time, by mortar of the same proportions and consistency, made of the same cement and standard Ottawa sand.

338. **Methods of Sampling and Testing.** The fine aggregate shall be sampled and tested in accordance with the methods described in articles 163 to 166 and 178 to 180, inclusive.

COARSE AGGREGATE.

338. **General.** The coarse aggregate shall consist of particles of clean, hard, tough, durable rock in the form of either gravel or crushed material. It shall contain no shale, slate, coal, ochre or other materials which easily disintegrate. It shall be free from vegetable or other deleterious matter, and shall contain no soft, thin or elongated pieces. In no case shall coarse aggregate containing lumps of frozen or partly cemented material be used.

339. **Crushed Stone.** When crushed stone is used, it shall be obtained from rock of fairly uniform quality, having a French coefficient of wear of not less than 6.

340. **Gravel.** Gravel used for coarse aggregate shall show high resistance to abrasion, and no gravel which in the opinion of the Engineer does not show wearing qualities at least equal to crushed stone having a French co-efficient of wear of 6 shall be used.

341. **Grading.** All coarse aggregate shall be well graded, and when tested by means of laboratory screens, shall meet the following requirements:

Passing 2½ inch screen	100%
Passing 2 inch screen	not less than 95%
Passing 1 inch screen	30% to 75%
Passing ¼ inch screen	not more than 5%

342. **Methods of Sampling and Testing.** The coarse aggregate shall be sampled and tested in accordance with the methods described in articles 167 to 172 and 176 to 177, inclusive.

UNSCREENED MATERIAL.

343. The use of pit run gravel or of a material made up of a mixture of the fine and coarse aggregates described above will not be permitted.

WATER.

344. The water used in mixing the concrete shall be clean, free from oil and organic matter, and when tested with litmus shall show no acid or alkaline reaction.

BITUMINOUS MATERIAL FOR CRACKS AND JOINTS.

345. **General.** The bituminous material used for filling cracks and joints may be either a coal tar product or an asphalt meeting the requirements of articles 346 to 363, inclusive.

SPECIFICATIONS REFINED TAR.

346. **Refined Coal Tar for Filling Cracks and Joints.** The tar shall be homogeneous and free from water. It shall conform to the following requirements:

347.	Specific gravity at 25°C./25°C. (77°F./77°F.)	1.220 to 1.280
348.	Melting point	40°C. (104°F.) to 46°C. (115°F.)
349.	Total distillate by weight:	
	To 170°C. (338°F.)	not over 0.5%
	To 300°C. (572°F.)	not over 15.0%
	Specific gravity of total distillate, 25°C./25°C. (77°F./77°F.)	not less than 1.030
	Melting point of residue	not over 75°C. (167°F.)
350.	Solubility in carbon disulphide	75.0% to 85.0%
351.	Inorganic matter (ash)	not over 0.5%

352. References to the methods of tests to be used in determining the characteristics specified in articles 347 to 351, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

SPECIFICATIONS OIL ASPHALT.

353. **Asphalt for Filling Cracks and Joints.** The asphalt shall be homogeneous and free from water. It shall conform to the following requirement:

354. Specific gravity at 25°C./25°C. (77°F./77°F.)........0.995 to 1.100

355. Melting point........45°C. (113°F.) to 60°C. (140°F.)

356. Ductility at 25°C. (77°F.)........not less than 30 cm.

357. Penetration at 25°C. (77°F.), 100 gm., 5 sec........90 to 120

358. Loss at 163°C. (325°F.), 5 hours........not over 1.0%

359. Penetration of residue at 25°C. (77°F.), 100 gm., 5 sec........not less than 60

360. Total bitumen........not less than 99.5%

361. Per cent of total bitumen insoluble in 86°B. naphtha........19.0 to 28.0

362. Fixed carbon........9.0% to 17.0%

363. **Brittleness Test.** A cylindrical prism of the asphalt, one (1) centimeter in diameter, after being maintained at a temperature of 5°C. (41°F.) for 20 minutes shall bend 180 degrees at any point without checking or breaking. The bending shall take place in one continuous operation requiring not more than ten (10) seconds.

364. References to the methods of tests to be used in determining the characteristics specified in articles 354 to 362, inclusive, are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

365. **Methods of Sampling and Testing.** The cement, sand, screenings, crushed stone, gravel, water and concrete shall be sampled and tested in accordance with the methods given in articles 162 to 180 for "Concrete Base Course," and the bituminous material shall be sampled and tested in accordance with the methods given in articles 272 to 277 and 290 to 302, for "Bituminous Concrete Pavement."

CONSTRUCTION.

366. **Placing Aggregate.** Both fine and coarse aggregate for the concrete may be delivered directly on the subgrade provided that the subgrade is sufficiently free from dust or mud to keep the materials free from adulteration. No material shall be deposited upon the subgrade until it has been shaped and brought to a true finish.

367. If the aggregates are deposited on the subgrade, the piles of the coarse and fine shall be kept separate, and shall be conveyed to the mixer in units which will insure accurate measurement of the volume of both fine and coarse aggregate.

367. The quantities of aggregates for each batch shall be exactly sufficient to be used with either one or more sacks of cement but no batch shall be run requiring fractional sacks of cement.

368. Care shall be taken in removing aggregates from the subgrade that no clay or earth is taken. Stone forks, approved by the Engineer, shall be used in removing the coarse aggregate from the subgrade.

369. **Side Forms.** The side forms for the concrete pavement shall be of steel. They shall be straight and shall be of a width equal to the thickness of the pavement at the edge. Forms having a less width will be permitted only on condition that they are supported in such manner as to secure proper rigidity and so as to retain the concrete from squeezing out under the forms. All forms shall be set with exactness to the required grade and alignment of the pavement and supported in such a position during the entire operation of tamping and finishing that they will not at any time deviate more than one-fourth (¼) inch from a straight edge ten (10) feet in length. The use of bent side forms will not be permitted. The use of intermediate longitudinal forms to support the templet shall not be permitted, except as may be necessary to construct a monolithic curb and gutter section. All steel forms shall be cleaned and oiled after each time they are used.

370. When special permit is given for tamping and finishing the concrete by hand, side forms of wood may be used. All form lumber shall be at least two (2) inches thick, straight and of a width equal to the thickness of the pavement at the edge. Warped or otherwise objectionable planks shall not be used. All forms shall be set with exactness to the required grade and alignment of the pavement and supported in such a position, during the entire operation of tamping and finishing, that they will not at any time deviate more than one-fourth (¼) inch from a straight edge ten (10) feet in length.

371. The contractor shall provide sufficient forms so that it will not be necessary to remove them within twelve (12) hours after the concrete is placed. Before concrete is deposited against the forms, they shall be clean.

372. **Proportions for Concrete.** The concrete for the pavement shall consist of one (1) part of cement, two (2) parts of fine aggregate and three and one-half (3½) parts of coarse aggregate. The aggregate shall be placed in the mixer in such a manner as to insure that a uniform amount of each class of aggregate and cement is used in each batch of concrete; and the method of measuring the aggregate, whether in wheelbarrows or otherwise, shall be approved by the Engineer, one (1) sack of cement to be considered as 0.95 cubic foot and all measures to be by volume.

373. **Use of Additional Cement.** With fairly well graded aggregates, one (1) cubic yard of the concrete will require approximately 1.61 barrels of cement. Should the aggregates be so graded that a larger amount of cement than 1.61 barrels per cubic yard of concrete will be required, the Contractor shall provide such additional cement at his expense.

374. **Checking Quantity of Cement Used.** The Engineer shall compare the calculated amount of cement required according to these specifications and accompanying plans with amounts actually used during each day's work, as determined by actual count of the number of sacks or batches of cement used each day. If the amount of cement used on any day is less by more than two (2) per cent of the amount hereinbefore required, the Contractor shall be required to remove all such sections and rebuild them according to these specifications at his expense.

375. **Consistency.** There shall be used such an amount of water that the consistency of all the batches will be uniform and so that the concrete will show a slump not greater than one (1) inch nor less than one-half (½) inch when subjected to the following test: A slump can being in the form of a frustum of a cone having a top diameter of four (4) inches, a base diameter of eight (8) inches and a height of twelve (12) inches shall be placed on its base and filled with concrete which shall be tamped until all voids are filled with concrete, and a slight film of mortar appears on the surface. The slump can shall then be removed slowly and the vertical settlement or "slump" of the concrete noted.

376. **Mixing Concrete.** Concrete shall be mixed in a batch mixer of a type approved by the Engineer. No mixer shall be used which requires less than one (1) sack of cement per batch.

377. The mixer shall either be equipped with an attachment for automatically locking the discharge, or it shall be accompanied by a time recording device that will prevent emptying the mixer until all the materials have been mixed together for the minimum time required.

378. The type of mixer shall insure uniform distribution of the materials throughout the mass until the mixture is uniform in color and smooth in appearance. All of the materials, including the water for each batch of concrete, shall be mixed at least one (1) minute while the drum revolves at the speed for which it was designed, but between fourteen (14) and twenty (20) revolutions per minute. If a thorough mixing of the concrete in the opinion of the Engineer is not affected by this process, a sufficient number of additional revolutions at the same rate shall be given it until a thorough mixing of each batch of concrete is secured. Any concrete mixed less than one minute as specified herein shall be dumped outside of the forms and removed from the road at the entire expense of the Contractor. The volume of material mixed per batch shall not exceed the manufacturer's rated capacity of the drum.

379. No material for a batch of concrete shall be placed in the drum of the mixer until all of the previous batch has been discharged therefrom. Water shall be added at the time the materials are being run into the mixer.

380. **Central Mixing Plants.** The use of a central mixing plant and the transportation of mixed concrete to the road will be permitted, provided that there is no segregation of the concrete when it arrives at the point where it is to be deposited in the road, and provided that the period of time that has elapsed from the time the concrete is mixed until it is deposited in the road does not exceed forty (40) minutes.

381. **Retempering.** Mortar or concrete which has partially set shall not be retempered by mixing the mortar or concrete with additional materials or water.

382. **Concrete Shall not be Placed During Freezing Weather.** Concrete shall not be mixed or placed when the temperature is below 35°F.

383. All concrete shall be effectively protected from the action of frost for a period of at least five (5) days after it is deposited in the work. All concrete which has not been properly protected as above specified and concrete which may have become damaged by frost shall be replaced at the Contractor's expense upon written notice from the Engineer. Concrete shall not be placed on a frozen sub-grade.

384. **Placing and Finishing Concrete Pavement.** The concrete shall be placed between the side forms at least to the full thickness of the pavement and in successive batches for the entire width. After the concrete has been deposited it shall be leveled off from one-half (½) to three-quarters (¾) of an inch higher than the finished pavement by means of a templet independent of the tamping templet and then tamped mechanically with a machine approved by the Engineer, until all voids are removed and the concrete is thoroughly compacted. The mechanical tamper shall go over each area of the pavement at least five (5) times and at such intervals as will give the desired results. The mechanical tamper shall be kept in good repair at all times and shall operate so as to give the entire surface of the pavement repeated blows. The vertical stroke of the tamper shall be at least one (1) inch in length.

385. The finished pavement shall be uniform in character and appearance and free from voids and depressions and true to the cross sections shown on the plans. Portions of the pavement showing voids in the concrete after finishing and removal of the side forms shall be rejected.

386. Hand tamping and finishing will not be permitted except in case of a break-down or other emergency and then only upon special permit from the Engineer. In case hand tamping and finishing are used, at least one man per 150 lineal feet of pavement laid per day and at no time less than two (2) men shall be engaged at the exclusive work of tamping the concrete. The tamping templet shall have a tamping face of approximately four (4) inches and shall have a sufficient rigidity to maintain the true cross section of the road.

387. **Finishing Surface of Concrete Pavement—Mechanical Tamping.** The concrete shall be tamped mechanically, and the surface of the pavement shall be finished as follows:

388. Immediately after the final tamping, the surface shall be belted over once with a combined cross-wise and longitudinal motion. In case the belt attached to the finishing machine does not produce the desired results, in the opinion of the Engineer, independent belts shall be supplied and used. Care shall be taken not to work the crown out of the pavement, nor to permit the edges of the belt to dig into the surface of the concrete.

389. If there is a surplus of water or an appreciable amount of laitance from the cement on the surface of the pavement after tamping, the surface shall be rolled in the manner specified under paragraph 392 before final belting.

390. When the surface of the pavement is free from water and just before the concrete obtains its initial set, the surface shall be given a final belting in order to produce a uniform surface. The final belting shall be of short; rapid, transverse strokes, having a sweeping longitudinal motion. Badly worn belts must be discarded and new ones supplied.

391. **Finishing Surface of Concrete Pavement—Hand Tamping.** If the concrete is tamped by hand, the surface of the pavement shall be finished as follows:

392. Immediately after the final tamping it shall be rolled, the roller being slowly operated transversely from one edge of the pavement to the other, and then back again over the same area. A one-half lap shall then be made and the rolling continued as before until the entire surface has been rolled. In moving the roller to make the lap, great care shall be taken not to mar or displace the concrete.

393. Immediately after the rolling, the surface shall be belted and before the concrete obtains its initial set, it shall be given a finish by final belting in order to produce a uniform surface. This belting shall be of short, rapid, transverse strokes having a sweeping longitudinal motion.

394. The belt shall be of canvas-rubber composition from two (2) to four (4) ply and shall have a width not less than six (6) inches, and a length at least two (2) feet longer than the width of the pavement. Preferably two (2) belts of different weights shall be used, the lighter one being used for the final belting.

395. The roller shall be of smooth steel approximately twelve (12) inches in diameter, and shall have a total length of six (6) feet. The weight shall not exceed one pound per inch of length of roller. The roller shall be operated by means of ropes.

396. The use of a short handled wood float as a substitute for the belt will be permitted only by the written authorization of the Engineer. If such permission is granted, the finishing shall be carried on from a suitable bridge no part of which shall come in contact with the concrete. The use of a long handled wood float is prohibited.

397. **Finishing Edges of the Pavement.** The edges of the pavement shall be carefully finished with an edger of about three-quarters of an inch radius at about the time the concrete takes its initial set. This work shall be done in such a manner that the edge will be left smooth and true to line.

398. **Joints.** At the close of each day's work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete has taken its initial set, a butt construction joint shall be made at right angle to the center line of the pavement.

399. For this joint there shall be used a clean plank having a thickness of not less than two (2) inches, a width not less than the thickness of the pavement and a length not less than the width of the pavement. The plank shall be cut true to the crown of the finished pavement and shall be accurately set and held to place in a plane at right angles to the longitudinal surface of the pavement. After the concrete has become partially set, the edge of the slab along the plank shall be just slightly rounded.

400. Upon the resumption of work, any surplus concrete remaining upon the subgrade will be removed. The plank shall be carefully removed and the fresh concrete deposited against the old in such a manner as to avoid interference with the edge of the old concrete.

401. After the concrete has become partially set, the edge of the slab along the construction joint shall be slightly rounded with an edging tool.

402. **Uneven Surface to be Remedied.** Before the concrete has taken its initial set, the surface of the pavement shall be tested for irregularities or waves by means of a ten (10) foot straight edge. Should there appear at a joint or other point on the concrete pavement surface any unevenness amounting to one-quarter ($\frac{1}{4}$) of an inch or over, above or below the general contour of the surface of the concrete as determined above, then the Contractor shall at once take such means as will be effective to remove such unevenness and produce a true and uniform surface. After the concrete has obtained its final set, no depressions shall be remedied by filling with concrete or other material unless the concrete slab has been cut so as to insure a thickness of at least four (4) inches for the new material and with sides cut vertical. If any such depression requires a patch of this character of over two (2) square feet in extent, then the entire slab of concrete shall be cut through to the foundation for the entire width of the road and new concrete placed so as to produce a true surface.

403. Should any portion of the surface of the concrete pavement when finished have a wavy effect, which produces a disagreeable effect to traffic, even though the depressions may not be as much as one-quarter (¼) of an inch, such portion of the pavement shall be entirely removed and replaced by a new slab of concrete.

404. **Protection and Curing of Concrete Pavement.** After the concrete pavement has been finished as above described, it shall be protected from the sun and wind with suitable frames covered with canvas. In case the pavement dries too rapidly, resulting in hair cracks or checking of the surface, the canvas shall be kept wet. As soon as the concrete sets sufficiently, canvas shall be laid directly upon the concrete and the canvas shall be kept wet if, in the opinion of the Engineer, it is necessary in order to protect and cure the pavement properly. As soon as practicable after the concrete has taken its final set and not later than ten (10) o'clock A.M. of the day following the placing of the concrete, all canvas shall be removed and the entire pavement shall be covered immediately with earth and thoroughly saturated with water or covered immediately with water held upon the surface of the pavement by means of dikes.

405. The protection of the surface by means of water held in place by dikes known as the "lake" or "ponding" method, is recommended as preferable to earth covering. When the "ponding" method of covering is used, the surface of the pavement shall be kept covered with water for a period of two (2) weeks.

406. If an earth covering is used, the edges of the pavement shall be banked with earth and the surface of the pavement shall be covered with at least two (2) inches of earth, said thickness being determined after the earth has been thoroughly saturated with water. The earth covering shall be thoroughly saturated with water twice each day at intervals of about twelve (12) hours for two weeks, and the covering shall remain upon the road for at least twenty (20) days from the time of its application and for a longer period of time, if weather conditions, in the opinion of the Engineer, make this desirable.

407. Upon written approval of the Engineer, straw may be substituted for the earth covering. When straw is used, it shall be at least six (6) inches thick after having been saturated with water, and shall be kept wet in the same manner as specified for the earth covering.

408. Before final acceptance of the work and at least ten (10) days before traffic is permitted on the pavement, the earth covering shall be scraped off by the Contractor and spread over the earth shoulders on either side of the covering in a thin, uniform layer. When straw is used for a covering material, it shall be removed from the pavement and disposed of so as to leave the road in a sightly condition.

409. When the average daily temperature is below 50°F. sprinkling or ponding may be omitted at the discretion of the Engineer, but the edges of the pavement shall be thoroughly banked with earth and the entire surface of the pavement covered with at least two (2) inches of earth for a period of two (2) weeks.

410. The pavement shall be kept closed to traffic for thirty (30) days, or if, in the opinion of the Engineer, the weather conditions make it advisable, the pavement shall be kept closed to traffic a longer period of time. In no event, however, shall there be any hauling on the concrete surface and metal shoulders until the pavement has been cleaned of all earth and other foreign material.

411. **Basis of Payment.** This work shall be paid for at the contract unit price per square yard for "Portland Cement Concrete Pavement" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

CONCRETE FOR STRUCTURES

412. **Description.** Concrete for structures shall be produced from Portland cement and fine and coarse aggregates of the quality herein specified. Unless otherwise specifically indicated on the plans, the concrete shall be one of the three classes known as Class "A," Class "B" or Class "X"; and shall be used where indicated on the plans or where directed, and in accordance with these specifications.

413. **Use of Class "A" Concrete.** All reinforced concrete, and all plain concrete masonry measuring less than ten (10) inches in thickness, except for floors on steel bridges, shall be made of Class "A" concrete unless otherwise shown on the drawings or directed in writing by the Engineer.

414. **Use of Class "B" Concrete.** Unless otherwise specified, Class "B" concrete shall be used in all plain concrete abutments, piers and wing walls, and shall also be used elsewhere as may be provided for on the plans or by the written directions of the Engineer.

415. **Use of Class "X" Concrete.** Unless otherwise specified, Class "X" concrete shall be used for all parapet walls, bridge seats and floors on steel bridges.

416. **Proportions for Class "A" Concrete.** Class "A" concrete shall consist of one (1) part cement, two and one-half (2½) parts fine aggregate and four (4) parts coarse aggregate passing a one and one-half (1½) inch screen and retained on a one-quarter (¼) inch screen.

417. **Proportions for Class "B" Concrete.** Class "B" concrete shall consist of one (1) part cement, three (3) parts fine aggregate and five (5) parts coarse aggregate passing a two and one-half (2½) inch screen and retained on a one-quarter (¼) inch screen.

418. **Proportions for Class "X" Concrete.** Class "X" concrete shall consist of one (1) part cement, two (2) parts fine aggregate and three and one-half (3½) parts coarse aggregate passing a one (1) inch screen and retained on a one-quarter (¼) inch screen.

419. The aggregate shall be placed in the mixer in such manner as to insure that a uniform amount of each class of aggregate and cement is used in each batch of concrete, and the method of measuring the cement and the aggregate shall be approved by the Engineer, one sack of cement to be considered as 0.95 cubic foot and all measures to be by volume.

420. **Materials.** The materials shall conform to the requirements of articles 143 to 161 for "Concrete Base Course," except that the coarse aggregate shall be of the size required in articles 416 to 418, inclusive.

421. **Rubble Concrete.** In Class "B" concrete placed in plain concrete piers, abutments and retaining walls having sections two (2) feet thick or more, "one man" stone may be used. When such stone is used, it shall be clean, sound and hard, and each piece shall be completely surrounded by a layer of concrete not less than six (6) inches thick. Unless otherwise specifically provided, suitable stone removed from the old structure, when such structure is to be removed by the Contractor, may be used in rubble concrete as described.

422. **Furnishing Material for Forms.** The Contractor shall provide all necessary material and means for building the forms for all concrete masonry. Surfaced and matched lumber shall be provided for all exposed surfaces.

423. **Construction of Forms.** All forms shall be so constructed as to be held rigidly in place, line and elevation. If at any point of the work, after the concrete has been placed, the forms show signs of bulging or sagging, that portion of the concrete shall be immediately removed on notice by the Engineer, and the forms shall be properly supported. The amount of concrete to be removed shall be determined by the Engineer, and no extra allowance shall be made to the Contractor for such work. All forms are to remain in place until, in the opinion of the Engineer, it is safe to remove them.

424. **Moulding.** Moulding having three-quarter (¾) inch or one (1) inch sides shall be used on all exposed corners. The surface of such moulding in contact with the concrete may be rounded to a uniform radius or may be flat. In the latter case, the resulting angles between adjacent surfaces in the finished concrete shall be equal.

425. **Beveled Faces.** Forms shall be given a bevel of one (1) inch to one (1) foot wherever projections of the concrete, such as copings, floor beams, etc., would otherwise cause binding upon the removal of the forms. The pitch shall be so arranged as to increase the thickness of copings, floor beams, etc., at the base, and the narrowest parts of such projections shall have dimensions not less than as shown on the plans.

426. **Mixing Concrete.** Concrete shall be mixed in a batch mixer of a type approved by the Engineer. The type of mixer shall insure uniform distribution of the materials throughout the mass until the mixture is uniform in color and smooth in appearance. All of the materials including the water for each batch of concrete, shall be mixed at least one minute while the drum revolves at the speed for which it was designed, but between fourteen (14) and twenty (20) revolutions per minute. If a thorough mixing of the concrete, in the opinion of the Engineer, is not effected by this process, a sufficient number of additional revolutions at the same rate shall be given until a thorough mixing of each batch of concrete is secured. Any concrete mixed less than one (1) minute as specified herein, shall be dumped outside of the forms and removed from the work at the entire expense of the Contractor. The volume of material mixed per batch shall not exceed the manufacturer's rated capacity of the drum. No material for a batch of concrete shall be placed in the drum of the mixer until all of the previous batch has been discharged therefrom. Water shall be added at the time the materials are being run into the mixer.

427. **Consistency.** The amount of water used in mixing concrete shall be just sufficient to flush to the surface with vigorous spading or troweling. An excess of water will not be permitted. The consistency of all batches shall be uniform.

428. **Retempering.** Concrete shall be mixed in such quantities that a batch can be placed in the work within thirty (30) minutes from the time of mixing. No concrete which has taken an initial set and which requires retempering shall be used

429. **Placing.** All concrete shall be carefully deposited in place in such a manner that the stone and mortar are not separated.

430. **Spading.** As fast as concrete is deposited, it shall be thoroughly settled by spading or other means to bring the mortar in thorough contact with the forms and reinforcing steel.

431. **Continuous Placing.** If possible, all the concrete in any slab, girder, arch, or wall shall be poured continuously. For arches, concreting shall begin at the springing lines and be carried along from both springing lines symmetrically toward the crown.

432. **Placing in Layers.** Concrete shall be placed in continuous horizontal layers in walls and girders. No plane of set will be allowed at a distance of less than eighteen (18) inches below the top of walls or girders. In floors the concrete shall be placed for the full thickness, and the construction of the floor carried along in this manner.

433. **Construction Joints in Floor Slabs.** If joints in floor slabs are necessary, they shall be made in vertical planes located at right angles to the main reinforcing steel and near the middle of the slab span, except for concrete floors on steel bridges, in which case the joint shall be vertical at right angles to the axis of the roadway and over the center of a floor beam.

434. **Construction Joints in Walls.** If at any time the work is interrupted so that the concrete already deposited attains its initial set, the surface of such concrete shall be chipped off for a sufficient depth to expose the coarse aggregate, the loose material swept or washed away, the surface thoroughly wetted and flushed with a thin 1 to 2 mortar before concreting is resumed.

435. When it becomes necessary to cease concreting for a period of twenty-four (24) hours or more, grooves shall be formed in the top surface of the concrete by embedding timbers. When concreting is resumed these timbers shall be removed and the entire surface of the concrete shall be cleaned and flushed as indicated above. As an alternative, one-man stone embedded one-half (½) their thickness may be substituted for the formation of grooves.

436. **Construction Joints in Arches.** Construction joints in arches shall be at right angles to the main reinforcing steel and the axis of the arch and shall be located as directed by the Engineer. When more than two runs are required to pour an arch the concrete shall be poured in alternative blocks extending across the entire width of the arch to insure uniform settlement in the falsework. The blocks shall be located as directed by the Engineer.

437. **Protecting Concrete While Curing.** Concrete floor slabs on all types of bridges shall be protected from the direct rays of the sun by means of canvas, straw or other means approved by the Engineer, and shall be kept wet continuously for a period of two (2) weeks after they are placed.

438. **Freezing Weather.** Concrete to be left above the surface of the ground or water shall not be constructed during freezing weather except on the express written consent of the Engineer, and it shall be protected in the manner ordered by the Engineer.

439. **Placing Concrete Under Water.** Concrete shall not be placed in running water and shall be placed in still water only with suitable appliances and under the direction of the Engineer.

440. **Cofferdam.** Suitable and practically water-tight cofferdams preferably of steel sheet piling or tongue and groove wood piling shall be used whenever water-bearing strata are encountered above the elevation of the bottom of the excavation. The inside dimensions of pits and cofferdams shall be sufficiently large to give easy access to all parts of the foundation forms.

441. **Pumping.** Pumping will not be permitted from the inside of foundation forms while concrete is being placed, and if necessary to prevent flooding, a seal of concrete shall be placed through a chute or by means of bottom dump buckets, and allowed to set.

442. **Removal of Forms.** The forms covering what will be the exposed face of the concrete masonry shall be removed as soon as the Engineer decides that it is safe to do so, and all crevices neatly filled with a stiff 1 to 2 cement mortar thoroughly rammed into place. All exposed faces shall be brought to a smooth, neat surface by rubbing with a block of wood and sand or a carborundum brick, while the concrete is green.

443. **Removal of Falsework.** Falsework supporting concrete structures, shall not be removed until the concrete has attained sufficient strength to allow same with safety. Under ordinary weather conditions, falsework shall remain in place after concreting has been completed for at least one day for each foot of span length, with a minimum of two (2) weeks for short spans and up to thirty (30) days for spans of thirty (30) feet or more. The Contractor may be required to leave falsework in place for a longer period of time if the Engineer considers it necessary.

444. **Mortar Surfaces.** All top surfaces such as the top of retaining walls, abutments, girders, floors, etc., shall be treated by tamping and troweling in such a manner as to flush the mortar to the surface and provide a smooth, even surface, free from pits and porous places. If necessary to secure such a surface, a thin layer of mortar consisting of one (1) part of cement to two (2) parts of sand shall be applied evenly, and troweled smooth before the concrete has set.

445. **Finishing Surface of Floor Slabs.** When traffic is to come directly upon the surface of a floor slab, it shall be finished as provided for "hand tamping" and "hand finishing" under "Portland Cement Concrete Pavement," articles 386 and 391 to 396.

446. **Drainage Openings.** Drainage openings through abutments, wing-walls and retaining walls shall be constructed in the manner and where indicated on the plans, or as directed, and no additional compensation shall be allowed for such work.

447. **Maintaining Batter.** Should it be found necessary, in the judgment of the Engineer, to increase or decrease the depth of the foundations from that shown on the plans, the thickness of the wall, where said wall joins the footing, shall be increased or decreased the same amount per foot as the main wall increases per foot of its height as shown on the plans.

448. **Extra Foundation Work.** Should it be found necessary to carry the foundations to a depth exceeding three (3) feet below that shown on the plans, the Contractor shall be paid, in addition to the contract prices stated in the "Proposal," an amount equal to the cost of completing that part of the foundation below said three (3) feet plus fifteen (15) per cent of said cost. The cost shall be considered as made up of the cost of materials, plus the actual cost of the labor, but shall not include any charge for overhead, rental, depreciation of equipment, or other expense.

449. **Basis of Payment.** This work shall be paid for at the contract unit price per cubic yard for "Class A Concrete," "Class B Concrete," and "Class X Concrete," as the case may be, complete in place, which price shall include all materials, equipment, tools, labor, excavation and work incidental thereto.

. REINFORCEMENT.

450. **Description.** Unless otherwise shown on the drawings, all steel for reinforcement in concrete shall consist of plain square section bars or deformed bars of a type to be approved by the Engineer. Round bars may be used in place of the square bars shown on the plans, providing an equivalent area of steel is used and on condition that any such substitution be plainly shown on a set of plans and the same be submitted to the Engineer for approval before the steel is ordered.

451. **Material.** Unless otherwise provided, all steel for reinforced concrete shall be of "Structural Steel Grade" or "Intermediate Grade," and shall comply with the requirements of the "Standard Specifications for Billet-Steel Concrete Reinforcement Bars" of the American Society for Testing Materials as given in A. S: T. M. Standards 1918, Serial Designation A15-14, except that any material received on the work and which does not show the required physical properties may be rejected by the Engineer. No rerolled material or high carbon steel shall be used on the work.

452. **Size of Bars.** The cross section of all reinforcing bars shall have the area required and it shall be understood that the size of all steel reinforcement as indicated on the plans is the size of a square equivalent to the required net section. All bars shall be obtained in the full lengths indicated on the plans.

453. **Cleaning.** Before steel is placed in the concrete, it shall be free from grease, dirt or rust, and the Contractor shall provide means on the work for properly cleaning the steel.

454. **Placing.** The steel bars shall be distributed in the concrete in the exact positions and have the net sectional area provided in the drawings. In general, they shall be securely wired or otherwise fastened in place before concrete is deposited.

455. **Bedding.** Special care shall be exercised to insure thorough contact of the concrete with every portion of the surface of the steel reinforcement.

456. **Basis of Payment.** Reinforcing steel shall be paid for at the contract unit price per pound for "Reinforcing Steel," complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto. No payment shall be made except for reinforcing steel incorporated in finished work.

BRICK MASONRY

457. **Description.** Brick masonry for hand rails on bridges or where otherwise specified shall be constructed in accordance with these specifications.

458. **Brick.** The brick shall be uniform in size, hard, and evenly burned, firm and compact in structure, and free from laminations, checks, or other defects. All exposed faces of the brick shall have a rough texture similar to that of a stiff-mud, wire-cut face brick. The brick shall be of a light color, preferably buff or light tan, which will harmonize with concrete. A reasonable variation in color shall be permitted. Samples of the brick shall be submitted to the Engineer for approval before the order is placed.

459. **Mortar.** The mortar shall be composed of one (1) part of Portland cement and two (2) parts of sand, with sufficient mineral coloring matter to produce the desired shade. The cement and the water used in making the mortar shall comply with the requirements of articles 143 to 147 and article 161 for "Concrete Base Course," and the sand shall comply with the requirements of articles 148 to 152.

460. **Construction.** Brick masonry shall be constructed in conformity with the dimensions and the design indicated on the plans. The brick shall be thoroughly drenched with clean water immediately before laid. The brick shall be laid in mortar colored as directed by the Engineer. The mortar shall be of the same general color as the brick but several shades darker. All joints shall be raked out to a depth of three-eighths (3/8) of an inch.

461. **Basis of Payment.** This work shall be paid for at the contract unit price per cubic yard for "Brick Hand Rail" complete in place, which price shall include all materials, equipment, tools, labor, excavation and work incidental thereto.

462. Should the Engineer require the use of brick which costs more than thirty-five (35) dollars per thousand F. O. B. cars at the nearest available railroad siding, the Contractor shall be paid in addition to the sums named in the "Proposal" the excess cost of such brick, over and above thirty-five (35) dollars per thousand, F. O. B. cars.

DRAINAGE STRUCTURES

463. **General.** All bridges, culverts, retaining walls, and similar structures, shall be constructed where shown on the plans, in accordance with the design and dimensions shown upon the plans, and in accordance with the specifications contained herein.

464. **Materials.** Unless otherwise specifically provided, all materials shall comply with the requirements of the specifications herein contained for the class of work or type of construction involved.

465. **Construction Methods.** All structures shall be constructed in accordance with the specifications herein contained for the type of construction involved, and when completed shall conform to the lines, grades, dimensions and designs shown on the plans.

466. **Basis of Payment.** Drainage structures shall be paid for at the contract unit prices stated in the "Proposal" for each class of work or type of construction.

UNDERDRAINS

VITRIFIED PIPE UNDERDRAIN.

467. **Description.** This underdrain shall consist of vitrified pipe laid in a trench back-filled with a coarse aggregate to a minimum depth of four (4) inches above the upper surface of the tile, and shall be constructed in conformity with the dimensions, location, alignment and grade shown on the plans, and in accordance with these specifications.

468. **Pipe.** The pipe shall be of first quality, double strength, sound vitrified stoneware sewer pipe with bell and spigot joints. It shall be hard burned, without warps, cracks, blisters or other imperfections, and shall be smoothly salt-glazed. It shall have the full rated dimensions both for diameter and length.

469. **Coarse Aggregate.** The coarse aggregate shall consist of broken stone or other fairly hard material approved by the Engineer. In general, broken stone or other aggregate passing a two (2) inch screen and retained on a three-quarter (3/4) inch screen shall be used, except that the aggregate used to fill the pockets at fifty (50) foot intervals shall pass a three (3) inch screen and be retained on a one and one-half (1½) inch screen.

470. **Construction Methods.** The trench shall be excavated carefully to the required depth and the bottom of the trench shall be finished smooth and firm.

471. The pipe under-drain shall be laid carefully to line and grade with bells up-stream. When the pipe is laid in quick sand or other unstable material, hay, straw or cinders shall be placed around each joint of pipe to act as a strainer. The trench shall be back-filled to a minimum depth of four (4) inches above the upper surface of the tile with coarse aggregate or clean cinders approved by the Engineer. The remainder of the trench shall be back-filled with the excavated material, except that at intervals of fifty (50) feet the material for back-filling shall consist of coarse aggregate or cinders as above mentioned. At these intervals of fifty (50) feet the back-filling material shall constitute pockets for the accumulation of water, these pockets to be the full width and depth of the trench and to be at least five (5) feet in length between the vertical planes.

472. **Head Walls.** Head walls shall be built around outlets of underdrains as shown or directed, and in conformity with the plans and in accordance with the specifications for "Concrete for Structures."

473. **Basis of Payment.** This work shall be paid for at the contract unit price per linear foot for "Vitrified Pipe Underdrain," complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

GUTTERS

CONCRETE GUTTERS.

474. **Description.** Concrete gutters shall consist of Portland cement concrete and shall be constructed on a prepared subgrade in conformity with the dimensions indicated on the plans, and in accordance with these specifications.

475. **Materials.** All materials for concrete gutters constructed in connection with cement concrete pavements shall comply with the requirements of articles 327 to 344, inclusive. In all other types of construction, all materials for concrete gutters shall comply with the requirements of articles 143 to 161, inclusive.

476. **Proportions.** All concrete for gutters shall consist of one (1) part of cement, two (2) parts of fine aggregate and three and one-half (3½) parts of coarse aggregate.

477. **Checking Quantity of Cement.** The quantity of cement used shall be checked as described in articles 373 and 374.

478. **Construction.** Concrete gutters built with a concrete pavement shall be constructed monolithic with the pavement, and concrete gutters built with a pavement on a concrete base shall be constructed monolithic with the base. All workmanship and construction details relating to concrete gutters shall comply with the requirements for concrete pavement or concrete base respectively.

478A. **Basis of Payment.** This work shall be paid for at the contract unit price per linear foot for "Concrete Gutter" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

CURBING

CONCRETE CURBING.

479. **Description.** The curbing shall consist of Portland cement concrete, and shall be constructed in conformity with the dimensions indicated on the plans and in accordance with these specifications.

480. **Materials for Concrete and Proportions to be Used.** The materials for the concrete, the proportions of the materials to be used in the concrete, and the methods of checking the quantity of cement shall be the same as required for concrete gutters, articles 474 to 478, the word "curbing" being substituted for "gutter" in each case.

481. **Bituminous Expansion Joint.** The bituminous expansion joint shall consist of suitable high grade felt or fibre combined with either asphalt or tar. It shall be one-half (½) inch in thickness, in lengths of not less than four (4) feet, and of the width shown on the plans.

482. **Composition of Expansion Joint.** No expansion joint shall be used until it has been approved by the Engineer as to composition and quality of component materials. In general it shall comply with the following requirements as to composition:

Inorganic (mineral) matter	not over 5%
Organic matter insoluble in carbon disulphide	not over 25%

483. **Sampling Bituminous Joint.** The samples of the bituminous expansion joints shall consist of pieces taken from the entire thickness and width of the joint. Each sample shall consist of at least three (3) pieces taken from three (3) separate sections of the joint and shall weigh not less than one (1) pound. It shall be shipped in a clean tin container properly labeled, and to which is securely attached a card giving full information relative to the sample.

484. **Testing Bituminous Joint.** Each sample used in the tests shall be selected to represent as nearly as possible the entire thickness and width of the joint. The following methods shall be used:

485. Inorganic (mineral) matter. U. S. Dept. of Agriculture Bulletin 314, p. 27.

486. Organic matter insoluble in carbon disulphide. By extraction with hot carbon disulphide in Soxhlet or other suitable extractor.

487. **Construction.** When concrete curbs are required with either a concrete base course or a concrete pavement, the curbs shall be built monolithic with the base course or pavement; and the use of a mechancial tamper for the section having the curbs will not be required. All workmanship relating to concrete curbs shall comply with the requirements for workmanship for concrete base course and concrete pavement respectively.

488. **Basis of Payment.** This work shall be paid for at the contract unit price per linear foot for "Curbing" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

GUARD FENCE

489. **Description.** Guard fence shall consist of wood railings supported by wood posts, and shall be constructed where indicated on the plans, and in accordance with these specifications.

490. **Wood Posts.** The wood posts used for the guard fence shall be made of seasoned, straight, sound chestnut, locust or red cedar. All posts shall be of the length indicated on the plans, and shall not be less than six (6) inches square or six (6) inches in diameter at the small end. Both round and square posts shall not be used in the same guard fence.

491. **Wood Railings.** The wood rails shall be made of first-class, well-seasoned, straight, sound yellow pine or other approved lumber, free from wind shakes, loose or unsound knots, decayed or sap wood, worm holes, or other defects. The rail shall be surfaced on all sides, and shall be of the dimensions indicated on the plans.

492. **Paint.** The material for painting the guard fence shall consist of white lead or zinc-lead paint meeting the approval of the Engineer. It shall be purchased in paste form or as a ready mixed paint, and the use of dry pigment which is mixed with the vehicle by the Contractor shall not be permitted. The vehicle shall consist of pure raw linseed oil with enough Japan of good quality or other approved drier to cause the paint to dry properly, but in no case shall the amount of drier exceed ten (10) per cent of the vehicle.

493. **Sampling and Testing Paint.** The paint shall be sampled and tested as described in articles 634 to 637, inclusive.

494. **Construction.** The guard fence shall be constructed in accordance with the plans. The posts shall be set vertically to the required alignment and the top rail and side rails shall break joints and be fastened securely to each post. Before erection all joints shall be painted, and after erection the entire fence shall be painted with two coats of the specified materials.

494A. **Basis of Payment.** This work shall be paid for at the contract unit price per lineal foot for "Guard Fence" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

SURVEY MONUMENTS

495. **Description.** This work shall consist of the preservation, relocation and erection of survey monuments which are discovered or known to exist within the limits of the proposed improvement.

496. When survey monuments are located within the limits of the proposed improvements they shall not be disturbed by the Contractor until the County Surveyor shall have made such references as may be necessary to preserve their location. When the pavement is laid the original location of the survey monument shall be identified by placing in the pavement vertically above or below the original location a cast iron plug six (6) inches square and three (3) inches thick. The plugs used for this purpose will be furnished by the County Surveyor and shall be set securely and in a workmanlike manner flush with the surface of the pavement in accordance with the requirements of the Law and under the directions of the County Surveyor.

497. All labor, tools and machinery used in the performance of preserving, relocating and identifying of monuments as well as the salary and expenses of the County Surveyor while engaged in this work shall be borne by the Contractor.

498. **Basis of Payment.** This work shall be paid for at the unit price for "Preserving, relocating and erecting Survey Monuments" shown in paragraph 15 of the Proposal.

RIPRAP

499. **Description.** Riprap shall consist of stones of suitable size and quality, laid where indicated on the plans and in accordance with these specifications.

500. **Stone.** The stone shall consist of hard, sound, angular pieces, of a size known as "one man stone," and no piece shall be less than six (6) inches in its smallest dimension.

501. **Construction.** The stone shall be laid by hand with as close joints as possible. Spalls shall not be used. The surface of the completed riprap shall have the alignment shown on the plans, each stone being in close contact with all surrounding pieces.

502. **Basis of Payment.** This work shall be paid for at the contract unit price per square yard for "Riprap" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

TIMBER PILING

503. **Description.** Bearing piles shall be of timber placed as indicated on the plans, or as directed by the Engineer, and in accordance with these specifications.

504. **Material.** The piles shall consist of sound, straight timber of a variety which will stand driving without splitting or undue brooming. The bark shall be removed and all knots shall be trimmed close to the body of the pile. Each pile shall have a diameter of not less than eight (8) inches at the small end and ten (10) inches at the butt, and shall have sufficient length so that when all damaged wood has been cut off, the tops shall project about nine (9) inches above the bottom of the footing. The Contractor shall be responsible for determining the length of piles required, either by driving test piles, or otherwise.

505. The tops of piles shall not extend above the elevation of low water in the stream unless the piles are creosoted. When creosoted piles are required, the piles shall be treated with a creosote oil as specified in articles 651 to 669.

506. **Spacing.** Unless otherwise directed by the Engineer, piles shall be spaced not less than three (3) feet nor more than five (5) feet center to center.

507. **Loading.** When used, piles shall be considered as carrying the entire load. The maximum load carried by any pile of the minimum dimensions stated in article 504 shall not exceed ten (10) tons, nor shall the maximum load carried by any pile exceed fifteen (15) tons.

508. **Driving Piles.** The piles shall be driven plumb or to the batter indicated and spaced as shown upon the plans, or as directed by the Engineer. Either a gravity or steam hammer of approved type and weight may be used. Each pile shall be considered as having a safe supporting capacity found by the following formula:

$$P = \frac{2WH}{S+1} \text{ for gravity hammer.} \qquad P = \frac{2WH}{S+0.1} \text{ for steam hammer.}$$

In this formula, P = safe load in pounds, W = weight of hammer in pounds, H = the fall of the hammer in feet, and S = the penetration in inches under the last blow assumed to be sensible and at an approximately uniform rate. S must be measured only when there is no visible rebound of the hammer, and the blow must be struck on practically sound wood. If the head of the pile becomes broomed in driving, the top shall be cut off to sound wood before taking the measurement for S.

509. Unless otherwise indicated upon the plans or under "Special Provisions" each pile shall be driven until it will support a load of ten (10) tons, as determined by the above formula.

510. All piles shall be cut off at the required elevation.

511. **Basis of Payment.** This work shall be paid for at the contract unit price per lineal foot for "Untreated Piles" or "Creosoted Piles," as the case may be. Payment shall be made for the actual number of feet of piles left in place, and no allowance shall be made for cut-off or for any piles which are not driven in accordance with the specifications.

STRUCTURAL STEEL FOR BRIDGES

512. **Description.** Structural steel and iron shall comprise "Structural Steel" and "Rivet Steel," "Steel Castings," "Steel Forgings" and "Iron Castings."

MATERIALS.

513. **Structural Steel and Rivet Steel.** Steel for rivets and all steel for steel bridges such as beams, plates, bars, pins, etc., except castings and forgings shall comply with the requirements of the "Standard Specifications for Structural Steel for Bridges" of the American Society for Testing Materials as given in A. S. T. M. Standards 1918, Serial Designation A7-16. It shall be understood, however, that samples may be tested either at the manufacturing plant or at any such other place as may be designated by the Engineer, and all steel failing to comply with the requirements of the Specifications may be rejected at any time.

514. **Steel Castings.** Steel for castings shall conform to the requirements for Medium Grade, Class B castings of the "Standard Specifications for Steel Castings" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation A27-16. The castings may be tested in accordance with the method described under Section 11 of the specifications referred to in this article, but it shall be understood that the tests may be made in any laboratory designated by the Engineer and that steel castings failing to comply with the requirements of the specifications may be rejected at any time.

515. **Steel Forgings.** Steel for forgings shall conform to the requirements for Class C forgings of the "Standard Specifications for Carbon-Steel and Alloy-Steel Forgings" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation A18-18. It shall be understood that the tests may be made in any laboratory designated by the Engineer, and that forgings failing to comply with the requirements of the specifications may be rejected at any time.

516. **Iron Castings.** Iron castings shall conform to the requirements for "Light Castings" of the "Standard Specifications for Gray Iron Castings" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation A48-18. The tests may be made in any laboratory designated by the Engineer.

GENERAL FEATURES.

517. **Minimum Sizes.** The minimum thickness of metal shall be 5-16 inch except for fillers. Gusset plates shall be not less than ⅜ inch thick. The webs of beams and channels shall be not less than ¼ inch thick. No beam or channel less than 6 inches or angle having one or both legs, less than 2½ inches shall be used, except as hereinafter provided.

518. **Clearance.** For all through bridges there shall be a clear head room of not less than fifteen (15) feet above the crown of the finished roadway.

519. **Lower Laterals.** No permanent lateral bracing need be provided in the plane of the loaded chord, provided a solid concrete floor, reinforced in both directions is immediately to be placed on the structure. In this case, however, a temporary lateral system consisting of adjustable rods must be used to hold the chords in line while the floor is being placed. After the floor is completed, such temporary laterals must be removed. When permanent lower laterals are used they shall be bolted to the stringers at each intersection.

520. **Guard Fences.** Unless otherwise provided for on the drawings, the bridge shall be provided with a guard fence, consisting of two 5-inch 6.5 lb. steel channels on each side. The lower edge of the lower channel shall be 20 inches above the top of the floor and there shall be a 12-inch space between the channels.

521. The guard channels shall be rigidly attached to the posts and diagonals in such manner as to secure a straight alignment of the channels, and they shall have a length equal to at least the length, center to center, of end pins or bearings. Where supports other than truss members are necessary, such supports shall generally consist of 3 inch by 3½ inch by 5-16 inch angles. Flanges of guard channels at the ends of the bridge shall be **sheared at an angle of 45 degrees.**

DETAILS OF DESIGN.

522. **Field Connections.** Unless otherwise shown on the plans, all field connections other than pin connections, except for stringers bearing on the top flange of floor beams, and hand rails, shall be riveted.

523. **Stringers.** Stringers bearing on the top flange of floor beams shall be bolted to the floor beams and wall channels, where provided for, by two ⅝ inch bolts at each end.

524. **Open Sections.** Structures shall be so designed that all parts will be accessible for inspection, cleaning and painting.

525. **Pockets.** Pockets or depressions which would hold water shall have drain holes, or be filled with waterproof material.

526. **Symmetrical Sections.** Main members shall be so designed that the neutral axis will be as nearly as practicable in the center of the section, and the neutral axis of intersecting main members of trusses shall meet at a common point.

527. In pin connected members, where the pins are placed more than ½ inch from the neutral axis, the bending effect, due to the eccentricity of pins, shall be provided for.

528. **Counters.** Rigid counters are preferred, and where subjected to reversal of stress shall preferably have riveted connections. Adjustable counters shall have open turnbuckles.

529. The area of counters shall be determined by taking the difference in areas required by the live and dead load stresses considered separately.

530. **Combined Stresses.** When any member is subjected to the action of both axial and bending stresses as in the case of chords carrying distributed floor loads, it must be proportioned so that the greatest fibre stress will not exceed the allowed limits of tension or compression on that member.

531. If the fibre stress resulting from the weight only, of any member, exceeds ten per cent of the allowed unit stress on such member, such excess must be considered in proportioning the area.

532. **Net Section at Rivets.** In proportioning tension members the diameter of the rivet holes shall be taken 1-8 inch larger than the nominal diameter of the rivet.

533. The rupture of a riveted tension member is to be considered as equally probable, either through a transverse line of rivet holes or through a diagonal line of rivet holes, where the net section does not exceed by 30 per cent the net section along the transverse line.

534. The number of rivet holes to be deducted will be determined by this condition.

535. **Rivets.** In proportioning rivets the nominal diameter of the rivet shall be used. Rivets shall not be used to transmit stress except by shear or bearing.

536. **Net Section at Pins.** Pin-connected riveted tension members shall have a net section through the pinhole at least 25 per cent in excess of the net section of the body of the member, and the net section back of the pin hole parallel with the axis of the member, shall be not less than the net section of the body of the member.

537. **Angle Splices.** Both legs of angles carrying tension shall be connected. The number of rivets in each leg shall be in proportion to the net area of metal in that leg, but no connection shall have less than three (3) rivets.

538. **Proportioning Plate Girders.** Plate girders and built up beams and stringers shall be proportioned by assuming that the flanges are concentrated at their centers of gravity. One-eighth of the net section of the web, if properly spliced, may be used as flange section.

539. **Compression Flanges.** In beams and plate girders the compression flanges shall be made of the same **gross** section as the tension flanges.

540. **Flange Rivets.** The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer, in a distance equal to the effective depth of the girder, the total shear at any section together with any load that is applied directly on the flange.

541. **Web Plates.** The webs of plate girders must be stiffened at intervals not exceeding the depth of the girders or a maximum of five (5) feet, wherever the shearing stress per square inch exceeds the stress allowed by the following formula:

542. Allowed shearing stress 12,500 — 90 H, where H = ratio of depth of web to its thickness; but no web plate shall be less than 5-16 inch in thickness.

543. **Stiffeners.** All stiffeners must be capable of carrying the maximum vertical shear without exceeding the allowed unit stress found by the formula: $P = 12{,}000 - 55\ l/r$.

544. Each stiffener must be connected to the web by enough rivets to transfer the maximum shear to or from the web.

545. **Rolled Beams.** Rolled beams shall be proportioned by their moments of inertia.

546. **Pitch of Rivets.** The minimum distance between centers of rivet holes shall be not less than three (3) diameters of the rivet; but the distance shall preferably be not less than 3 inches for ⅞ inch rivets, 2½ inches for ¾ inch rivets, and 2¼ inches for ⅝ inch rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be not more than six (6) inches for ⅞ inch rivets, five (5) inches for ¾ inch rivets, four and

one-half (4½) inches for ⅝ inch rivets, nor more than 16 times the thickness of the thinnest outside plate. For angles with two gauge lines and rivets staggered, the maximum shall be twice the above in each line. Where two or more plates are used in contact, rivets not more than 12 inches apart in either direction shall be used to hold the plates well together. In tension members composed of two angles in contact, a pitch of 12 inches will be allowed for riveting the angles together.

547. **Edge Distance.** The minimum distance from the center of any rivet hole to a sheared edge shall be 1½ inches for ⅞ inch rivets, 1¼ inches for ¾ inch rivets and 1⅛ inches for ⅝ inch rivets, and to a rolled edge 1¼ inches, 1⅛ inches and 1 inch respectively. The maximum distance from any edge shall be eight (8) times the thickness of the plate, but not to exceed five (5) inches.

548. **Maximum Diameter.** The diameter of the rivets in any angle carrying calculated stress shall not exceed one-quarter of the width of the leg in which they are driven. In minor parts ⅞ inch rivets may be used in 3 inch angles, and ¾ inch rivets in 2½ inch angles.

549. **Long Rivets.** Rivets carrying calculated stress and whose grip exceeds four (4) diameters shall be increased in number at least one (1) per cent for each additional 1-16 inch grip.

550. **Pitch at Ends.** The pitch of rivets at the ends and each way from intermediate panel points of built up compression members shall not exceed four (4) diameters of the rivet, for a length equal to one and one-half times the maximum width of the member.

551. **Compression Members.** In compression members the metal shall be concentrated as much as possible in webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between its connection to the flanges. Cover plates shall have a thickness not less than one-fortieth of the distance between rivet lines.

552. **Minimum Angles.** Flanges of girders and built up members without cover plates shall have a minimum thickness of one-twelfth of the width of the outstanding leg.

553. **Tie Plates.** The open sides of compression members shall be provided with lattice bars and shall have tie-plates as near each end as practicable. Tie plates shall be provided at intermediate points where the lattice is interrupted. In main members the end tie plates shall have a length not less than the distance between the lines of rivets connecting them to the flanges; intermediate ones, not less than one-half this distance. Their thickness shall be not less than one-fiftieth of the same distance.

554. Unless otherwise specified, riveted tension members shall be provided with batten plates at intervals of not more than five feet; each end of each batten to be connected to the flanges of the member by not less than 4 rivets.

555. **Lattice Bars.** The minimum width of lattice bars and the size of the connecting rivets shall be as follows:

15 inch channels or built up sections with angles over three (3) inches, width 2½ inches; rivets ⅞ inch.

12 and 10 inch channels or built up sections with angles over three (3) inches, width 2½ inches; rivets ¾ inch.

8 and 9 inch channels, width 2 inches; rivets ⅝ inch.

6 and 7 inch channels, width 1¾ inches; rivets ⅝ inch.

556. Single lattice bars shall have a thickness not less than 1-40 or double lattice bars connected by a rivet at the intersection, not less than 1-60 of the distance between the rivets connecting them to the members. They shall be inclined at an angle not less than 60 degrees with the axis of the member for single latticing, nor less than 45 degrees for double latticing with riveted intersections. Lattice bars shall be so spaced that the portion of the flange included between their connections shall be as strong as the member as a whole.

557. **Abutting Joints.** In continuous compression members, abutting joints shall be placed as close to the panel points as practicable. Abutting joints with milled faces shall be provided with a splice plate on each side of the web or plate spliced, and shall have at least two rows of closely pitched rivets on each side of the joint.

558. Compression members having abutting joints with untoothed faces and all riveted tension members must be fully spliced. Adjacent ends must, however, be dressed straight and true so there will be no open joints. All hip joints must be fully spliced.

559. **Pin Plates.** Pin holes shall be reinforced by plates where necessary, and at least one plate shall be as wide as the flange will allow and be on the same side as the flanges or angles. They shall contain sufficient rivets to distribute their portion of the pin pressure to the full cross-section of the member. At least one of these plates shall extend not less than 6 inches beyond the near edge of the tie plate.

560. **Pins.** Pins shall be long enough to insure a full bearing of all the parts connected upon the turned body of the pin. They shall be secured by chambered nuts. The screw shall be long enough to admit of burring the threads.

561. **Filling Rings.** Members packed on pins shall in all cases be held against lateral movement by means of ring fillers.

562. **Bolts.** Wherever bolts are used in place of rivets, the holes shall be reamed parallel while the members are fitted in place and the bolts turned to a driving fit.

563. Where members are connected by bolts, the turned unthreaded shank shall be long enough to extend through the metal connected. A washer at least ¼ inch thick shall be used under the nut. Bolts shall not be used in place of rivets except by special permission. Heads and nuts shall be hexagonal.

564. **Indirect Splices.** Where splice plates are not in direct contact with the parts which they connect, as in case fillers are used, rivets shall be used in excess of the number theoretically required to the extent of one-third of the number for each intervening plate.

565. **Bolsters and Rockers.** All bridges having spans of more than 80 feet, shall have cast hinged bolsters on one end and cast hinged rockers on the other end, said bolsters and rockers to be of a design approved by the County Superintendent of Highways.

566. **Shoes for Pony Trusses.** The end gusset plates of pony trusses shall be connected to the base plate with angles having 2 rows of rivets in the vertical leg. All bearing surfaces of the base plates and vertical webs shall be planed. No base plate or web connection angle shall have a thickness of less than ½ inch.

567. **Diaphragms.** The end gusset plates of pony trusses shall be connected transversely with a diaphragm.

568. All the bed plates and bearings under fixed and movable ends shall be fox-bolted to the masonry; for trusses, these bolts shall be not less than 1⅛ inches in diameter and 18 inches long; for plate and other girders, not less than ⅞ inch in diameter and 18 inches long. The Contractor shall furnish all bolts, drill all holes and set bolts to place with sulphur or Portland cement.

569. While the expansion ends of all trusses must be free to move longitudinally under changes of temperature, they shall be anchored against lifting or moving sideways.

570. Allowance shall be made for a change of length of bridge, due to a variation of temperature of 75 degrees either way from the normal.

FLOOR SYSTEM.

571. **Floor Beams.** Floor beams shall be riveted directly to the trusses and shall be faced true and square, and to correct lengths. Allowance shall be made in the thickness of the end angles to provide for such facing without reducing the required effective strength of the angles.

572. **End Spacers for Stringers.** Where end floor beams cannot be used, stringers resting on masonry shall have channel spacers near their ends.

573. Such spacers shall be rigidly bolted to the masonry at the fixed end of the bridge and the stringers shall be rigidly bolted to the spacer. At the free end the spacer shall be rigidly bolted to the masonry and slotted holes shall be provided either in the stringers or the spacer and the stringers bolted in such manner as to allow free longitudinal but no lateral movement. The slotted holes shall be long enough to provide for a change of length of bridge due to a variation of temperature of 75 degrees either way from the normal.

BRACING.

574. **Rigid Bracing.** Lateral, longitudinal and transverse bracing in all structures shall be composed of rigid members with riveted connections and shall be securely riveted at their intersection to prevent sagging and rattling.

575. **Portals.** Through truss spans shall have riveted portal braces rigidly connected to the end posts and top chords. They shall be as deep as the clearance will allow.

576. **Transverse Bracing.** Intermediate transverse frames shall be used at each panel of through spans having vertical truss members where the clearance will permit. Transverse frames shall be capable of transferring at least 0.7 of the wind load from the top to the bottom chord.

577. The top and bottom lateral systems shall, however, be designed to carry the entire wind load to the shoes in the usual manner.

TRUSSES.

578. **Camber.** Truss spans shall be given a camber by making the panel length of the top chords, or their horizontal projections, longer than the corresponding panels of the bottom chord in the proportion of ⅛ inch to 10 feet.

579. **Rigid Members.** Hip vertical and similar members, and the two end panels of the bottom chords of pin-connected trusses up to 300 foot spans, shall be rigid.

580. **Eye Bars.** Eye bars shall be straight and true to size, and shall be free from twists, folds in the neck or head, or any other defect. Heads shall be made by up-setting, rolling or forging. Welding will not be allowed. The form of heads will be determined by the dies in use at the works where the eye bars are made if satisfactory to the Engineer, but the manufacturer shall guarantee the bars to break in the body when tested to rupture. The thickness of the head and neck shall vary not more than 1-16 inch from that specified.

WORKMANSHIP.

581. **General.** All parts forming a structure shall be built in accordance with the approved working drawings. The workmanship and finish shall be equal to the best practice in modern bridge shops.

582. **Straightening Material.** Material shall be thoroughly straightened in the shop before being laid off or worked in any way.

583. **Finish.** Shearing shall be neatly and accurately done and all portions of the work exposed to view neatly finished.

584. **Size of Rivets.** The size of rivets called for on the plans shall be understood to mean the actual size of the cold rivet before heating.

585. **Rivet Holes.** When reaming is not required the diameter of the punch shall be not more than 1-16 inch greater than the diameter of the rivet, nor the diameter of the die more than ⅛ inch greater than the diameter of the punch. Material more than ¾ inch thick shall be sub-punched and reamed or drilled from the solid.

586. **Punching.** All punching shall be accurately done. Drifting to enlarge unfair holes will not be allowed. If the holes must be enlarged to admit the rivet, they shall be reamed. Poor matching of holes will be considered sufficient cause for rejection.

587. **Sub-Punching and Reaming.** Where reaming is required, the diameter of the punch used shall be at least 3-16 inch smaller than the normal diameter of the rivet. Holes shall then be reamed to a diameter of not more than 1-16 inch larger than the nominal diameter of the rivet. All reaming shall be done with twist drills in such a manner that the entire circumferences of the holes match perfectly.

588. **Reaming Field Connections After Assembling.** When reaming is required, it shall be done after the members meeting at a joint are assembled and firmly bolted together. If necessary to take the pieces apart for shipping and handling, the respective pieces reamed together shall be so marked that they may be assembled in the same position in the final setting up. No interchange of reamed parts will be allowed.

589. **Edge Planing.** Sheared edges or ends, shall, when required, be planed at least ⅛ inch.

590. **Burrs.** The outside burrs on reamed holes shall be removed.

591. **Assembling.** Riveted members shall have all parts well pinned up and firmly drawn together with bolts, before riveting is commenced. Contact surfaces shall be heavily coated with the paint herein specified before riveting.

592. **Lattice Bars.** Lattice bars shall have neatly rounded ends.

593. **Web Stiffeners.** Stiffeners shall fit neatly between flanges of girders. Where tight fits are called for, the ends of the stiffeners shall be faced and shall be brought to a true contact bearing with the flange angles.

594. **Splice Plate and Fillers.** Web splice plates and fillers under stiffeners shall be cut to fit within ⅛ inch of the flange angles.

595. **Web Plates.** Web plates of girders, which have no cover plates, shall be flush with the backs of angles or project above the same not more than ⅛ inch, unless otherwise called for. When web plates are spliced, not more than ¼ inch clearance between the ends of plates will be allowed.

596. **Connection Angles.** Connection angles for floor beams and stringers shall be flush with each other and correct as to position and length of girder.

597. **Rivets.** Shop rivets shall be driven by pressure tools wherever possible. Field rivets shall be driven by pneumatic tools. Hand driving will not be allowed.

598. **Riveting.** Rivets shall have a neat and finished appearance with heads of approved shape, full and of equal size. They shall be central on the shank and shall grip the assembled pieces firmly. Recupping and calking will not be allowed. Loose, burned or otherwise defective rivets shall be cut out and replaced. In cutting out rivets, great care shall be taken not to injure the adjacent metal. If necessary they shall be drilled out.

599. **Members to be Straight.** The several pieces forming one member shall be straight and fit closely together, and the finished member shall be free from twists, bends, or open joints.

600. **Finish of Joints.** Abutting joints shall be cut or dressed true and straight and fitted closely together, especially where open to view. In compression joints, depending on contact bearing, the surfaces shall be truly faced, so as to have even bearing after they are riveted up complete and when perfectly aligned.

601. **Eye Bars.** The eye bars composing a member shall be so arranged that the surfaces of adjacent bars shall not come in contact. They shall be as nearly parallel to the axis of the truss as possible, the maximum inclination of any bar being limited to one inch in 16 feet.

602. **Boring Eye Bars.** Before boring, each eye bar shall be properly annealed and carefully straightened. Pin holes shall be in the center line of bars and in the center of heads. Bars of the same length shall be bored so accurately that, when placed together, pins 1-32 inch smaller in diameter than the pin holes can be passed through the holes at both ends of the bars at the same time without forcing.

603. **Pin Holes.** Pin holes shall be bored true to gauge, smooth and straight, at right angles to the axis of the member and parallel to each other, unless otherwise called for. The boring shall be done after the member is riveted up.

604. **Variation in Pin Holes.** The distance center to center of pin holes shall be correct to within 1-32 inch and the diameter of the holes shall be not more than 1-50 inch larger than that of the pin, for pins up to 5 inches in diameter, and 1-32 inch for larger pins.

605. **Pins and Rollers.** Pins and rollers shall be accurately turned to gauge, shall be straight, smooth and entirely free from flaws.

606. **Screw Threads.** Screw threads shall make tight fits in the nuts and shall be U. S. Standard, except above the diameter of 1⅜ inches, when they shall be made with six threads per inch.

607. **Upset Ends.** All bars with screw ends shall be upset, so that the diameter at the bottom of the threads shall be 1-32 inch larger than any part of the body of the bar. Where closed sleeve nuts are used on adjustable members, the effective length of thread shall be legibly stamped at the screw end of each bar. Adjustable counters are to be avoided where practicable.

608. **Annealing.** Steel, except in minor details, which has been partially heated, shall be properly annealed.

609. **Welds.** Welds in steel will not be allowed.

610. **Bed Plates.** Expansion bed plates shall be planed true and smooth. Cast wall plates shall be planed, top and bottom. The cut of the planing tool shall correspond with the direction of expansion.

611. **Pilot Nuts.** Pilot and driving nuts shall be furnished for each size of pin.

INSPECTION.

612. **Facilities.** All facilities for inspection of the materials and workmanship shall be furnished by the Contractor.

613. **Test Pieces.** The Contractor shall furnish without charge such prepared specimens of the several kinds of steel to be used, as may be required to determine their character.

614. **Tests of Large Pieces.** Full sized parts of the structure may be tested at the option of the Engineer, but if tested to destruction, such material shall be paid for at cost, less its scrap value to the contractor, if it proves satisfactory. If it does not stand the specified tests, it will be considered rejected material, and be solely at the cost of the Contractor.

615. **Fabrication.** The Contractor shall notify the Engineer from time to time of the progress of fabrication and furnish every facility necessary for the Engineer to inspect the work in the fabricating shop. It is understood, however, that the Engineer may waive shop inspection and make complete inspection of all fabricated work when the same is delivered at the site of the bridge. Whether or not shop inspection is made, fabricated steel may be rejected at any time prior to final acceptance of the bridge provided it does not conform to the specifications.

BASIS OF PAYMENT.

616. This work shall be paid for at the contract unit price per pound for "Structural Steel" complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto; also all shop work, erection, paint and painting.

617. The weight to be paid for shall be the theoretical weight stated in the Proposal.

EXPANSION DEVICES FOR CONCRETE BRIDGES

618. **Description.** Unless otherwise shown on the plans, all reinforced concrete through or deck girder bridges, classed and designed as unrestrained structures shall be provided with expansion rockers at one end of each span.

619. **Rockers.** The rockers shall be made of cast iron of the kind and quality specified in article 516, and shall have the dimensions shown on the plans. All rockers shall have the bearing surfaces smooth and turned to a uniform radius, and shall be provided with two (2) inch holes through the web to facilitate handling.

620. **Bearing Plates.** The rockers shall turn between plates of mild or medium steel of the quality specified in article 513. The plates shall be not less than one (1) inch in thickness and the bearing surface of each plate shall be planed. The cut of the tool shall be in the direction of the expansion. Semi-steel plates two (2) inches thick may be used at the option of the Contractor.

621. **Heavy Oil for Rocker Pockets.** The heavy oil used for filling the rocker pockets shall be of the quality approved by the County Superintendent of Highways.

622. **Tar for Rocker Pockets.** Tar for filling rocker pockets shall be of the quality approved by the County Superintendent of Highways.

623. **Bituminous Felt.** The bituminous felt used to separate the superstructure from the substructure of concrete girder bridges at the free end and to separate adjacent superstructures of multiple span concrete girder bridges shall be provided in sheets having a manufactured thickness of one-half (½) inch and of the quality specified in articles 481 to 486, inclusive. Ordinary tarred or plain building paper shall not be used except for separating the superstructure and substructure of concrete slab bridges and at the fixed end of girder bridges.

624. **Rocker Pockets.** Pockets two (2) inches longer than the rockers shall be provided in the abutments and piers to receive the lower plates and the rockers. The lower plates shall be set in full mortar beds and accurately leveled, and at such an elevation that the top of the rockers will be one-half (½) inch above the surface of the concrete.

625. **Placing Rockers.** The rockers shall be placed accurately at right angles to the axis of the girders and supported in position by short soft wood wedges not more than one (1) inch wide placed between the ends of the rockers and the pockets. The wedges shall be soaked in water previous to driving and shall be driven only a sufficient amount to support the rockers in a vertical position. The pockets shall then be completely filled with heavy oil or tar of the quality herein specified.

626. **Placing Top Plates.** The top plates shall be placed in contact with the rockers and carefully leveled. The top plates may be supported by sticks having a cross-section of not more than one (1) inch and placed vertically, one on each side of the rocker and resting on the bottom of the pocket.

627. **Placing Bituminous Felt.** The bituminous felt cushion shall be placed where shown on the plans and when used to separate the superstructure concrete from that of the substructure at the free end of a girder bridge, it shall cover the entire top surface of the abutment or pier and extend under the edges of the top rocker plates at least one (1) inch.

628. **Placing Concrete Over Rocker Pockets.** In placing concrete over the rocker pockets, care shall be used to prevent the concrete from entering the pockets. If necessary to prevent leakage into the rocker pockets, sand or mortar shall be placed along the edges of the rocker plates before concrete is deposited.

629. **Basis of Payment.** Expansion devices for concrete bridges are included in the contract unit price per cubic yard for "Class A Concrete" or "Class B Concrete," as the case may be, and no additional compensation shall be allowed the Contractor for furnishing and installing same.

PAINTING

630. **Description.** The work shall consist of the painting of fabricated steel in the shops and of new or old steel bridges in the field.

631. **Paint.** The material for painting shall be of the quality herein described and shall be applied in conformity with the requirements of these specifications. Ready mixed paints, freshly prepared, or pigments in paste form to be mixed with a suitable vehicle, shall be used. Mixed paints which have hardened on standing or which have thickened, "livered" or otherwise deteriorated to any extent will not be acceptable and the use of dry pigment mixed with the vehicle by the Contractor will not be permitted.

632. **Red Lead Paint.** This paint shall be composed of high grade red lead pigment mixed with pure raw linseed oil and a suitable drier. The pigment shall contain not less than ninety-five (95) per cent of true red lead (Pb^3O^4) and not to exceed one (1.0) per cent of substances other than lead oxides. The vehicle shall consist of not less than ninety (90) per cent of pure raw linseed oil mixed with enough drier free from rosin to cause the paint to dry properly. The linseed oil shall comply with the requirements of the "Standard Specifications for Purity of Raw Linseed Oil from North American Seed" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation D1-15. The paint when ready for application shall contain not less than seventy-two (72) nor more than seventy-eight (78) per cent of pigment by weight. When the red lead is purchased in paste form, enough paste shall be added to the linseed oil and drier to obtain a paint containing the required per cent of pigment. With pastes containing about seven (7) per cent of oil this will require the addition of approximately forty (40) pounds of paste to each gallon of linseed oil. The red lead paint shall be sampled and tested in accordance with the requirements of articles 634 to 637, of these specifications.

633. **Sublimed Blue Lead Paint and Sublimed White Lead Paint.** These paints shall be composed of pure sublimed blue lead or sublimed white lead pigments respectively, mixed with pure boiled linseed oil. The paint when ready for application shall contain not less than fifty (50) nor more than fifty-four (54) per cent of pigment by weight. Should the pigment be in paste form, enough paste shall be added to the boiled linseed oil to produce a paint showing not less than fifty (50) nor more than fifty-four (54) per cent of pigment. The vehicle shall consist of pure boiled linseed oil complying with the requirements of the "Standard Specifications for Purity of Boiled Linseed Oil from North American Seed" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation D11-15. The addition of a small amount of turpentine or of drier, or the use of raw linseed oil with a drier will not be permitted unless specifically approved by the Engineer. The paint shall be sampled and tested in accordance with the requirements of articles 634 to 637 of these specifications.

634. **Methods of Sampling and Size of Samples.** Samples shall be taken from all materials used in painting. The samples shall represent the average of each material and shall be taken, in general, from closed containers received in the shop or in the field, but check samples may also be taken by Inspectors from the paint being actually applied on the steel. No material for painting shall be used until approved by the Engineer, and the Contractor shall, therefore, secure the necessary paint in ample time, so that no delay will be caused by the time necessarily used in testing, for which ten (10) days shall be allowed from the time the sample is received in the laboratory. Ready mixed paints or pastes shall be mixed carefully by very thorough stirring before samples are taken. A sample of ready mixed paint shall consist of not less than one (1) pint of the material. When the pigment is purchased in paste form, samples of not less than one (1) pound of the paste and one (1) pint of the linseed oil shall be taken for testing purposes. Samples of the driers which are to be used with raw linseed oil shall consist of not less than one-half (½) pint of the material.

635. **Shipment of Samples.** All samples shall be shipped in clean tin containers with tight fitting covers. They shall be properly labeled, and each sample shall be accompanied by a card, securely attached, giving full information relative to the sample.

636. **Per Cent of Pigment.** The per cent of pigment shall be determined by extracting a weighed amount of about fifty (50) grams of the paint or thirty (30) grams of the paste several times with light paraffin naphtha (preferably of 86° Beaume) using approximately 50 cc. of fresh naphtha for each extraction and repeating the operation until the liquid of extraction remains clear. The extraction and washing of the pigment shall be completed by the use of two or three portions of about 50 cc. of ether, the pigment finally dried to constant weight at 105°C., and the per cent of pigment by weight calculated. One hundred (100) less the per cent of pigment found shall be considered as the per cent of vehicle.

637. **Analysis of Pigment.** The determination of the per cent of true red lead, and of total lead oxides in red lead pigments, shall be made in accordance with the "Standard Methods for Routine Analysis of Dry Red Lead" of the American Society for Testing Materials as given in A. S. T. M. Standards, 1918, Serial Designation D49-18.

The purity of sublimed white lead and sublimed blue lead pigments shall be determined from the composition of the pigments as compared with the composition of samples of approved quality. The composition of each test sample and of the standard sample shall be obtained through the same standard methods of chemical analysis.

638. **Painting of New Steel.** Three coats of paint shall be used on all new steel. The shop coat shall consist of either red lead paint or sublimed blue lead paint, but both paints shall not be used on the steel for the same structure. The second coat, which shall be applied in the field, shall consist of a mixture of eighty (80) per cent sublimed white lead paint and twenty (20) per cent sublimed blue lead paint. The third coat shall consist of pure sublimed blue lead paint or of sublimed blue lead paint tinted as directed by the Engineer.

639. **Painting of Old Bridges.** Two coats of paint shall be applied on old steel bridges. The first coat shall consist of pure sublimed blue lead paint. The second coat shall consist of a mixture of eighty (80) per cent sublimed white lead paint and twenty (20) per cent sublimed blue lead paint.

640. **Applying Shop Coat.** The paint shall not be applied until shop inspection of the steel has been made. All steel shall be received and painted under cover and no painting shall be done in wet or freezing weather. All metal work, including railings and stringers, shall be cleaned from all rust, scale, dirt or grease, and shall be thoroughly dry before the first coat of paint is applied. If rust, which in the opinion of the Engineer cannot be removed, is found on any piece, that piece shall be rejected. All parts which come in contact shall be painted two coats before they are riveted together. Round brushes shall be used. Pieces and parts which are not accessible for painting after erection, including tops of stringers, eye bar heads, ends of posts, chords, etc., shall have two coats of paint before leaving the shop. While metal work is being erected in place, all abrasions of the original paint and all rivet and bolt heads and location marks shall be cleaned and painted, preparatory to the second coat.

641. **Machined Surfaces.** Machined surfaces shall be coated with white lead and tallow before shipment or before being placed in the open.

642. **Applying Field Coats.** After the structure is complete in place, touched up as described above, and cleaned from all rust, scale, dirt, grease and oil that may have accumulated during erection, two coats of paint shall be applied and well brushed out, each coat to be applied only after the previous coat has become thoroughly dry, allowing at least one week for this purpose. No painting shall be done in wet or freezing weather.

643. **Cleaning Old Bridges.** When the contract requires the painting of an old steel bridge, all steel work in the structure shall, by means of the sand blast or with scrapers, wire brushes and painter's torch, be cleaned from all loose paint, scale, rust, dirt and other foreign material, with the utmost care. The character of the cleaning shall be equal to that produced by the sand blast and not more than twenty-four (24) hours shall intervene between the cleaning and the application of the first coat of paint.

644. **Painting Old Bridges.** Immediately before the application of the first coat, the steel shall be thoroughly dusted with a soft brush or a clean cloth. Two coats of paint shall be applied and well brushed out, the second coat to be applied only after the first coat has become thoroughly dry, allowing at least one week for this purpose. No painting shall be done in wet or freezing weather.

645. **Basis of Payment.** The painting of new steel is included in the contract unit price per pound for "Structural Steel" and no additional compensation shall be allowed the Contractor for such work. The painting of old steel bridges shall be paid for in accordance with the contract price for such work stated in the "Proposal."

CREOSOTING

646. **Description.** The work shall consist in the treatment with creosote under pressure of wood blocks, piling, plank and other lumber for bridges.

647. **Wood Blocks.** Except as otherwise indicated in the following articles, the wood blocks shall comply with the "Tentative Specifications for Wooden Paving Blocks for Exposed Pavements" of the American Society for Testing Materials as given in the 1918 proceedings of the society under serial designation D52-18T. In case of conflict between the specifications referred to and the following articles, the following articles shall prevail.

648. **Dimensions of Blocks.** Unless otherwise shown on the plans, the depth of the blocks shall be three (3) inches.

649. **Piles, Planks and Other Lumber for Bridges.** The timber used for piles, creosoted plank, sub-planking, nailing pieces, shims, retaining pieces, and all other lumber for bridges except paving blocks, shall be strictly first-class red oak, spruce, Douglas fir, long leaf or short leaf pine, and shall be cut from green standing timber and thoroughly seasoned before treatment. It shall be straight grained, free from shakes, large or loose knots, decayed wood, bark, worm holes or any other defects that would impair its strength or durability or would prevent the proper creosoting of the lumber.

650. **Dimensions of Lumber.** The material shall be sawed straight and true, and unless otherwise noted shall be of standard commercial dimensions corresponding to the nominal dimensions shown on the plans. Lumber for plank and sub-planking shall be three (3) inches thick and from eight (8) inches to twelve (12) inches in width. When so indicated on the plans, the lumber shall be surfaced before creosoting.

651. **Preservative.** The preservative used in the treatment of the blocks, piles, plank or other lumber shall comply with the requirements for "Coal-Tar Paving Oil" or for "Distillate Oil" of the tentative specifications of the American Society for Testing Materials referred to in article 647. The character of the oil shall be as indicated in the "Proposal," and unless otherwise shown on the plans, the preservative used for piles, plank, and all bridge lumber except blocks, shall comply with the requirements for "Distillate Oil." On small contracts requiring the use of creosoted blocks and of treated piles, plank or other bridge lumber, a preservative complying with the requirements for "Coal-Tar Paving Oil" may be used, however, on written approval of the Engineer, for the treatment of the bridge lumber as well as for the wood blocks.

652. **Methods of Sampling and Testing Preservative.** Wood blocks, piles or bridge lumber shall not be treated until samples of the preservative to be used have been approved by the Engineer. These preliminary samples shall be taken from drip valves during the pumping of the material or from storage tanks at three different levels. When plant inspection is made check samples may also be taken from the drip valves or from tanks during the treatment. Each sample shall consist of not less than one (1) quart of the preservative and shall be shipped in a clean tin container with tight fitting cover. The sample shall be properly labeled and shall be accompanied by a card, securely attached, giving name of shipper and full information relative to the material represented. All tests of the material shall be made in accordance with the "Standard Methods for Sampling and Analysis of Creosote Oil" of the American Society for Testing Materials, as given in A. S. T. M. Standards, 1918, Serial Designation D38-18.

653. **Notification of Treatment.** After the preliminary samples of preservatives have been approved, the Creosoting Company shall notify the County Superintendent of Highways a sufficient length of time in advance of the date the material for the contract will be creosoted, so that an Inspector may be sent from Chicago, Illinois, to the creosoting plant, and arrive in time to inspect the material and check the treatment.

654. **Failure to Give Notice of Treatment.** Should the Creosoting Company fail to notify the Superintendent of Highways of the date the material is to be treated as heretofore provided, then a field determination of the quantity of creosote oil contained in the blocks or lumber may be made as the Engineer may direct. In general, this inspection of creosoted material shall be made as described in articles 661 to 669, inclusive. In addition, the Creosoting Company shall furnish the same certified statement as required when plant inspection is waived, article 655.

655. **Plant Inspection May be Waived.** Should the Creosoting Company be notified in writing that plant inspection of the treatment of the material will be waived, the Creosoting Company shall furnish a certified statement, signed by proper officers of the company showing that the material consists of blocks, piles or lumber of the quality prescribed and was treated in accordance with the requirements of these specifications. This certified statement shall include a copy of the analysis of the creosote oil made in accordance with the methods referred to in article 652, and shall indicate the amount of oil injected and remaining in the creosoted material.

656. **Creosote Oil Treatment.** The treatment of piles, plank or other bridge lumber shall be as described for wood blocks in the tentative specifications of the American Society for Testing Materials referred to in article 647. The steam and vacuum treatments of blocks and bridge lumber previous to the injection of the preservative shall be considered essential parts of the process of creosoting, and it shall be understood that all creosoted material showing more than fifteen (15.0) per cent of moisture by weight when tested as described under "Field Inspection" may be rejected by the Engineer.

657. **Quantity of Oil in Treated Material.** In calculating from gauge readings the amount of oil injected in the material under treatment, correction shall be made for losses due to leaks and other sources of waste of oil, and for any oil remaining in the cylinder or unabsorbed on the surface of the treated material. When a plant is not equipped with the necessary gauges, thermometers, draw cocks and other facilities to enable the Engineer to satisfy himself that the requirements of the specifications are being fulfilled or when the losses of preservative during treatment are such that in the opinion of the Engineer it becomes difficult to calculate from gauge readings the amount of preservative actually remaining in the treated material, the Engineer may require that the amount of oil injected be determined from a field inspection as described in articles 661 to 669. Determination of the amount of preservative in the material by weighing the loaded trucks before and after the treatment of the blocks or bridge lumber with preservative will be permitted when requested by the manufacturer.

658. **Handling of Creosoted Materials.** The blocks, piling, plank or other bridge material shall be placed on the trucks in such a position as to facilitate the thorough draining of any preservative remaining on the creosoted material. The accumulation of sawdust or other foreign material in the treating cylinders shall not be permitted. All materials shall be handled with care both before and after treatment, and it shall be understood that creosoted material which is otherwise satisfactory may be rejected if found to be coated with dirt.

659. **Quantity of Oil to be Used in Piles and Bridge Lumber.** Piles, plank and other bridge lumber shall show an average for each charge of not less than ten (10) pounds of creosote per cubic foot of material and each piece shall show a satisfactory penetration of the preservative.

660. **Inspection After Treatment.** All blocks which have been warped, checked or otherwise damaged during treatment, or which have been cut from defective material or which are not true to dimensions shall be rejected. All blocks noticeably deficient in creosote shall also be rejected and if the number of such deficient blocks should be larger than twenty (20) per cent of the lot or shipment, the entire lot or shipment shall be rejected. Plank or other bridge lumber which have been badly warped, checked or otherwise injured during treatment, or which show defects impairing their strength or durability or which are noticeably deficient in creosote shall also be rejected as described for blocks.

661. **Field Inspection of Treated Material.** In field inspection the determination of the quantity of creosote injected and actually remaining in the treated material shall be made as described in articles 662 to 669 of these specifications. While the description in articles 662 to 669 refers to the determination of the quantity of creosote in treated blocks, the same general procedure shall apply to piles, plank and other bridge lumber, the extractions being made from three-quarter (¾) inch borings taken as directed by the Engineer.

662. **Sampling Wood Blocks.** A sample shall consist of ten (10) blocks selected to represent as nearly as possible the average material. One sample shall be taken in general for each seven hundred (700) square yards of roadway to be paved, but in no case shall less than ten (10) blocks be selected from any lot or shipment. The blocks selected shall be numbered from 1 to 10 and the face of each block shall be divided in four (4) equal parts by one line parallel to the sides of the block and one line parallel to the ends. One quarter section from each block shall again be divided in five (5) equal parts by lines parallel to the ends of the block and these portions shall be numbered in the same manner from 1 to 5 in each block. The blocks shall then be sawed or split through their entire depth parallel to the ends and faces, each section following the lines of the portions referred to. Portions shall be taken from each block for an average sample as follows: Portion No. 1 from blocks No. 1 and 6, portion No. 2 from blocks No. 2 and 7, portion No. 3 from blocks No. 3 and 8, portion No. 4 from blocks No. 4 and 9, portion No. 5 from blocks No. 5 and 10. These portions from the various blocks shall be shredded or broken into small fragments which may be readily extracted with a suitable solvent, care being taken that no appreciable quantity of creosote is lost during the preparation of the sample. The shreds or chips shall be well mixed and kept in a tightly closed, non-absorbent container until used for the moisture determination and extraction tests.

663. **Moisture.** The moisture will be determined by the standard Forest Service method as outlined in Circular No. 134 of the U. S. Forest Service.

664. **Total Extract.** About thirty (30) grams of the thoroughly mixed creosoted chips shall be placed in a Soxhlet extraction apparatus and extracted with chloroform until the latter on passing through the chips is no longer discolored. The chips shall then be dried at 110 degrees C. until of constant weight, all of the moisture being evaporated at this temperature. The difference in weight of the chips before and after extraction will be taken as the weight of water, creosote, rosin and turpentine, contained in the chips.

665. **Rosin.** The chloroform extract shall then be distilled down to about one hundred cc. and saponified with five (5) per cent sodium carbonate (Na_2CO_3) solution. The aqueous solution of sodium resinate shall be acidified, the rosin removed with ether, and the ether distilled off. The residue shall be resaponified with a five

(5) per cent solution of sodium acid carbonate ($NaH CO_3$), the aqueous liquid acidified, and the rosin removed with ether. The ethereal rosin solution shall be transferred to a tarred glass crystallizing dish and evaporated, and the residue dried at 110 degrees C.

666. **Turpentine.** The turpentine shall be calculated from the amount of rosin found.

667. **Creosote.** The creosote shall be determined by subtracting the percentages of moisture, rosin and turpentine from the per cent of total extract and a correction added for the amount of matter insoluble in benzol found in the analysis of the oil.

668. **Specific Gravity.** The calculations shall be based on the specific gravity of the material, obtained by weighing and measuring the samples.

669. **Requirements of Tests.** Should the amount of oil found by the above described tests be less by more than ten (10) per cent from the amount required for blocks or less by more than twenty (20) per cent from the amount required for piles and bridge lumber, the creosoted material shall be rejected. It shall be understood that these variations from the required amounts include all allowances for variations in sampling and for losses of preservative from all sources.

670. **Basis of Payment.** The furnishing of creosoted blocks, piling, plank or other lumber is included in the contract unit prices for work requiring such materials, and no additional compensation over and above these unit prices shall be allowed the Contractor for furnishing such materials when so required.

SPECIAL BRIDGE FLOORS

UNTREATED PLANK FLOOR.

671. **Description.** Untreated plank floors shall consist of untreated plank with nailing pieces constructed in accordance with the plans and the requirements of these specifications.

672. **Material.** Unless otherwise indicated on the plans, all lumber shall be first-class white or burr oak, sawed true, straight grained and free from any defects that would impair its strength or durability. The plank shall be three (3) inches thick and eight (8) to twelve (12) inches wide, and shall be sawed to uniform length. Unless otherwise indicated on the plans, three (3) nailing pieces shall be provided and they shall be at least four (4) inches by six (6) inches in size.

673. **Construction.** The nailing pieces shall be rigidly bolted to the outside joists and the middle joists by means of ⅝-inch bolts spaced not more than three (3) feet apart. Nailing pieces bolted to the side of beams or channels shall have the top of the nailing piece flush with the top of the beam or channel.

674. All plank for untreated plank floors having no special wearing surface shall be laid heart side down with close joints, and with their ends in a straight line. The plank shall be spiked to the nailing pieces with three (3) wire spikes at each intersection. Such spikes shall have a length equal to at least double the thickness of the plank.

675. Wherever the head or nut of a bolt or lag screw would otherwise come in contact with the lumber, a standard size washer shall be used underneath the head or nut.

CREOSOTED PLANK FLOOR.

676. **Description.** Creosoted plank floors shall consist of creosoted plank with nailing pieces constructed in accordance with the plans, and the requirements of these specifications.

677. **Material.** All plank and other lumber used in creosoted plank floors shall comply with the requirements of articles 646 to 669, inclusive.

678. **Construction.** Creosoted plank floors shall be constructed as described under "Untreated Plank Floors," articles 673 to 675, inclusive.

CREOSOTED BLOCK FLOORS.

679. **Description.** Creosoted block floors shall consist of creosoted wood blocks with bituminous filler and expansion joints laid on felt cushion over creosoted sub-planking, constructed in accordance with the plans, and the requirements of these specifications.

680. **Creosoted Material.** All creosoted material, including blocks, sub-planking and other bridge lumber shall comply with the requirements of articles 646 to 669, inclusive. Ship-lap or tongue and groove sub-planking shall be used and shall be surfaced one side and the edges milled to lap not less than one (1) inch. The depth of groove and tongue adjacent to the surfaced side shall be dimensioned from the surfaced side so that a tight joint will be secured when the plank are laid surfaced side down. The plank shall not vary more than one-sixteenth (1/16) of an inch from the standard commercial thickness for such lumber.

681. **Asphalt Filler.** The asphalt used for filler shall be homogeneous and free from water and shall conform to the following requirements:

682. Specific gravity at 25°C./25°C. (77°F./77°F.) .... 0.990 to 1.100

683. Flash point .... not less than 177°C. (350°F.)

684. Melting point .... not less than 55°C. (131°F.)

685. Penetration at 25°C. (77°F.), 100 gm., 5 sec .... 30 to 50

686. Loss at 163°C. (325°F.), 5 hours .... not over 2.0%

687. Penetration of residue at 25°C. (77°F.), 100 gm., 5 sec .... not less than 20

688. Total bitumen .... not less than 95.0%

689. Per cent of total bitumen insoluble in 86°B. naphtha .... 18.0 to 30.0

690. Fixed carbon .... 9.0% to 17.0%

691. References to the methods of tests to be used in determining the characteristics specified above are given in articles 290 to 302, and the methods of sampling in articles 275 to 277, inclusive.

692. **Coal Tar Pitch Filler.** Coal tar pitch filler shall be homogeneous and free from water, and shall conform to the following requirements:

693. Specific gravity at 25°C./25°C. (77°F./77°F.)..............................1.250 to 1.350

694. Melting point..60°C. (140°F.) to 70°C. (158°F.)

695. Total distillate by weight, to 300°C. (572°F.)..............................not over 5.0%

696. Solubility in carbon disulphide..70.0% to 80.0%

697. Inorganic matter (ash)..not over 0.5%

698. References to the methods of tests to be used in determining the characteristics specified above are given in articles 290 to 302, and the methods of sampling in articles 272 to 277, inclusive.

700. **Bituminous Felt.** The bituminous felt used between the sub-planking and blocks shall be one-quarter (¼) inch in thickness and shall comply with the requirements of articles 481 to 486, inclusive.

701. **Placing Nailing Pieces.** The nailing pieces shall be placed as described in article 673.

702. **Sub-Planking.** The sub-planking shall be laid surfaced side down, and unless otherwise shown on the plans, shall be fastened to the outside nailing pieces by means of two 6-inch lag screws, at each end of each plank, and to the intermediate nailing pieces by means of three wire spikes having a length equal to at least double the thickness of the plank. Wood shims when called for on the plans shall be rigidly spiked to the sub-planking.

703. **Calking.** After the sub-planking and retaining pieces have been laid, all joints, which in the opinion of the Engineer are not sufficiently tight to prevent the leakage of the bituminous material used in the wearing surface, shall be calked with oakum by forcing it into the cracks with a proper calking tool in such manner as to form a practically water-tight joint, leaving the surface of the calking not less than ⅛ inch nor more than ¼ inch below the surface of the sub-planking.

704. **Retaining Pieces.** Retaining pieces for block floors shall be fastened by means of bolts, as shown on the plans.

705. **Washers.** Wherever the head or nut of a bolt or lag screw would otherwise come in contact with the timber, a standard size washer shall be used underneath the head or nut. All vertical bolts shall have the nut at the lower end.

706. **Lag Screws.** Holes for lag screws shall be bored slightly smaller in diameter than the shank of the lag screws and have a depth of one and one-half (1½) inches less than the length of the screw below the head. The holes shall be bored with a slight inclination from the center of the plank.

707. **Countersinking.** Countersinking shall be resorted to whenever the heads of screws or bolts would otherwise interfere with assembling the work. Recesses formed by countersinking shall be filled with hot asphalt or tar.

708. **Laying Felt Cushion.** After the sub-planking and retaining pieces have been laid and all joints calked, the sub-planking shall be covered with a thin layer of asphalt or tar of the kind herein specified. Immediately after the asphalt or tar has been spread it shall be covered with a layer of bituminous felt thoroughly rolled to contact with the asphalt or tar. The layer of felt so placed shall then be coated with a thin layer of bituminous material of the quality herein specified, and the creosoted blocks immediately laid thereon before the bituminous material has had time to cool.

709. **Laying Paving Blocks.** When required by the Engineer, the blocks shall be thoroughly wetted by repeated sprinkling at least twenty-four (24) hours before laying. The creosoted blocks shall be laid in regular courses at right angles to the center line of the roadway. The blocks shall be laid with ⅛ inch joints and shall be so laid that the blocks in adjacent rows will break joints by at least three (3) inches. Immediately after the blocks have been laid, they shall be rolled or tamped until firmly bedded in the bituminous cushion.

710. **Expansion Joints.** An expansion joint ½ inch wide shall be provided along each retaining piece and shall be kept free from obstruction during construction by means of a strip of wood one-half (½) inch thick extending entirely down to the felt cushion. After the wood block pavement has been laid and rolled or tamped, the wooden strips shall be removed from the expansion joints, which shall then be filled with asphalt or coal tar pitch filler as herein specified.

711. **Filling Joints.** The entire surface of the roadway shall, after the blocks have been laid, be gone over with a paint coat of the asphalt or pitch filler herein specified, which shall be applied at the temperature required by the Engineer. It shall be applied in such quantity as will completely fill all joints between blocks, using repeated applications if necessary. After the filler has been applied, the entire surface shall be covered with a light coating of clean coarse sand or granite chips of a size which will pass through a ¼-inch screen.

712. **Basis of Payment.** This work shall be paid for at the contract unit price per square yard for "Untreated Plank Floor," "Creosoted Plank Floor," "Creosoted Block Floor," as the case may be, complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

CATCH BASINS

713. **Description.** Catch basins shall consist of Portland cement concrete, and reinforcement if specified on the plans, and the necessary metal frames and covers or gratings, all constructed as shown on the plans and in accordance with these specifications.

714. **Materials.** Concrete catch basins shall be made of "Class A Concrete." Reinforcing bars, where called for, shall meet the requirements for "Reinforcing Steel." Castings for frames, covers. gratings, etc., shall meet the requirements for "Iron Castings," and shall be coated with coal tar pitch varnish.

715. Inlet and outlet pipes shall be of the same size and kind as the connecting pipe shown on the plans.

716. **Construction.** Concrete catch basins shall be constructed to the lines, grades and dimensions shown on the plans, and in accordance with the specifications for "Concrete for Structures."

717. Castings shall be set in full mortar beds or otherwise secured as shown on the plans.

718. Inlet and outlet pipes shall extend through the wall for a sufficient distance beyond the outside surface to allow for connections, and the concrete shall be constructed around them neatly so as to prevent leakage along their outer surface.

719. **Basis of Payment.** This work shall be paid for at the contract unit price each for "Catch Basins," complete in place, which price shall include all materials, forms, equipment, tools, labor and work incidental thereto—also all excavation and refilling around the structure and the disposal of surplus material; also the required frames and covers or gratings, the inlet and outlet pipes, and any other necessary fittings.

STONE WELLS

720. **Description.** This work shall consist of constructing stone wells at points indicated on the plans or as directed by the Engineer, all in accordance with the plans and these specifications.

721. **Materials.** The aggregate shall be of the same kind and size as specified for coarse aggregate for the pavement which is provided for in this improvement. Aggregate passing a one-quarter inch screen shall not be used unless authorized by the Engineer.

722. **Construction.** Stone wells shall be constructed in accordance with the design and dimensions shown on the plans.

723. **Basis of Payment.** This work shall be paid for at the contract unit price each for "Stone Wells," complete in place, which price shall include all materials, equipment, tools, labor, excavation and work incidental thereto.

BRIDGE NAME PLATES

724. **Description.** Two name plates shall be furnished and rigidly attached to the superstructure of each bridge having a span of more than eight (8) feet. The plates shall conform to the requirements of these specifications and the design furnished by the Engineer.

725. **Material.** The Contractor shall furnish two red or pink granite name plates for each bridge including setting and embedding same in the concrete at such a point as the Superintendent of Highways may direct.

726. **Description.** The name plates shall be approximately 14¼x14¼x3 inches. They shall be highly polished and the letters thereon shall be ⅝ inch high and recessed ⅛ inch deep. One plate shall contain the name of the Bridge, the name of the Township and County, and the names of the Bridge Engineer and the Contractor. The other plate shall contain the date, the name of the President of the County Board, names of the County Road and Bridge Committee, and the name of the Superintendent of Highways. The Contractor shall submit a drawing of the name plates, together with sample of the granite to the Superintendent of Highways for his approval before having the plates made.

727. **Basis of Payment.** Name plates shall be paid for at the contract unit price each for "Bridge Name Plates," complete in place, which price shall include all materials, equipment, tools, labor and work incidental thereto.

SECTION MARKERS

728. **Description.** This work shall consist of furnishing and erecting concrete section markers at points indicated on the plans or as directed by the Engineer, all in accordance with these specifications and the designs furnished by the Engineer.

729. **Materials.** The markers shall be made of Class X concrete, reinforced with four ¼-inch square bars of the quality specified for reinforcing steel. The material for painting the sunken letters shall be an iron oxide paint approved by the Engineer. Where black paint is required, lamp black shall be mixed with the iron oxide paint to produce the required color.

730. **Construction.** The forms shall be carefully made of first-class surfaced lumber or smooth metal and shall be cleaned thoroughly and oiled before concrete is placed. All edges shall be chamfered. The concrete shall be tamped in the forms so as to secure smooth mortar surfaces. The concrete shall be protected from the sun and kept wet for one (1) week after pouring.

731. At the termination of this period and when the concrete is thoroughly dry, the sunken figures and letters shall be given three (3) coats of paint of the quality specified in article 729. Each coat of paint shall be allowed to dry before the succeeding coat is applied.

732. **Erection.** Excavation shall be made to the required depth and the marker placed in exact vertical position and at right angles to the center line of the highway. The excavation shall then be backfilled in layers and tamped.

733. **Basis of Payment.** This work shall be paid for at the contract unit price each for "Section Markers," complete in place, which price shall include all materials, equipment, tools, labor, excavation, back filling and work incidental thereto.

SEEDING

734. **Description.** The work shall consist in the seeding after completion of the road construction as prescribed in the foregoing specifications of the sides of the highways from the right of way lines to the edge of the pavement. The seed shall consist of oats or wheat with clover sown in accordance with the requirements of these specifications. The seed shall be used to the best advantage in covering all places that are likely to erode badly, and all seed shall be harrowed or raked in.

735. **Sowing Clover.** Seven (7) bushels of oats or three (3) bushels of wheat, with one-third (⅓) of a bushel of clover shall be sown per mile of road. It shall be understood that oats shall be used prior to August 15th, and wheat on later sowings.

736. **Basis of Payment.** The cost of seeding is figured in the cost of the construction of the roadway and it is understood that no extra compensation shall be allowed for this work. If the Contractor fails to do the seeding, or if, in the opinion of the Engineer, it is deemed advisable to omit the seeding, it is understood that a deduction of thirty ($30.00) dollars per mile of road will be withheld from final payment to the Contractor.

SPECIAL PROVISIONS

737. All "Special Provisions" will be listed on separate insert sheets immediately following these specifications.

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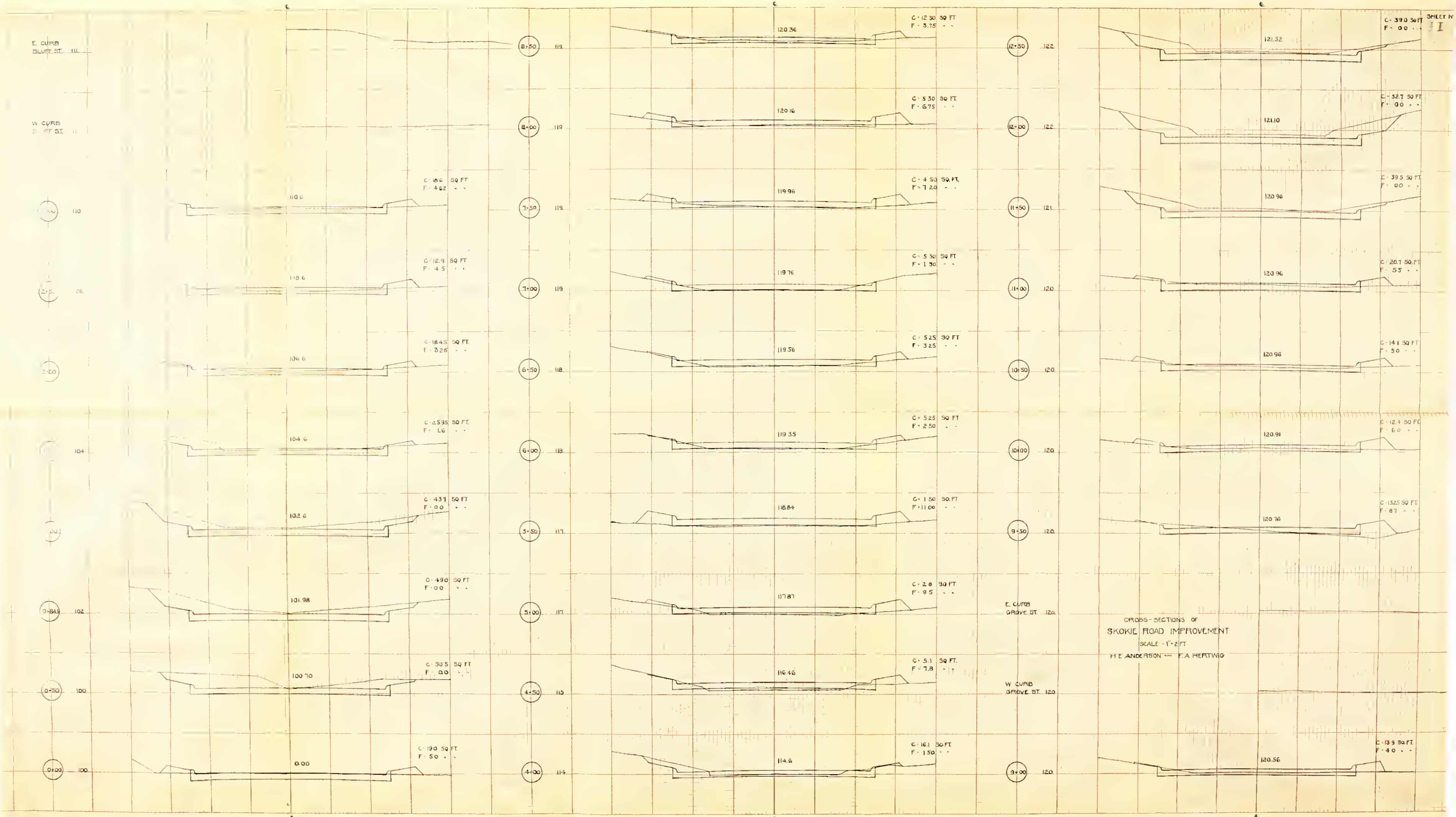
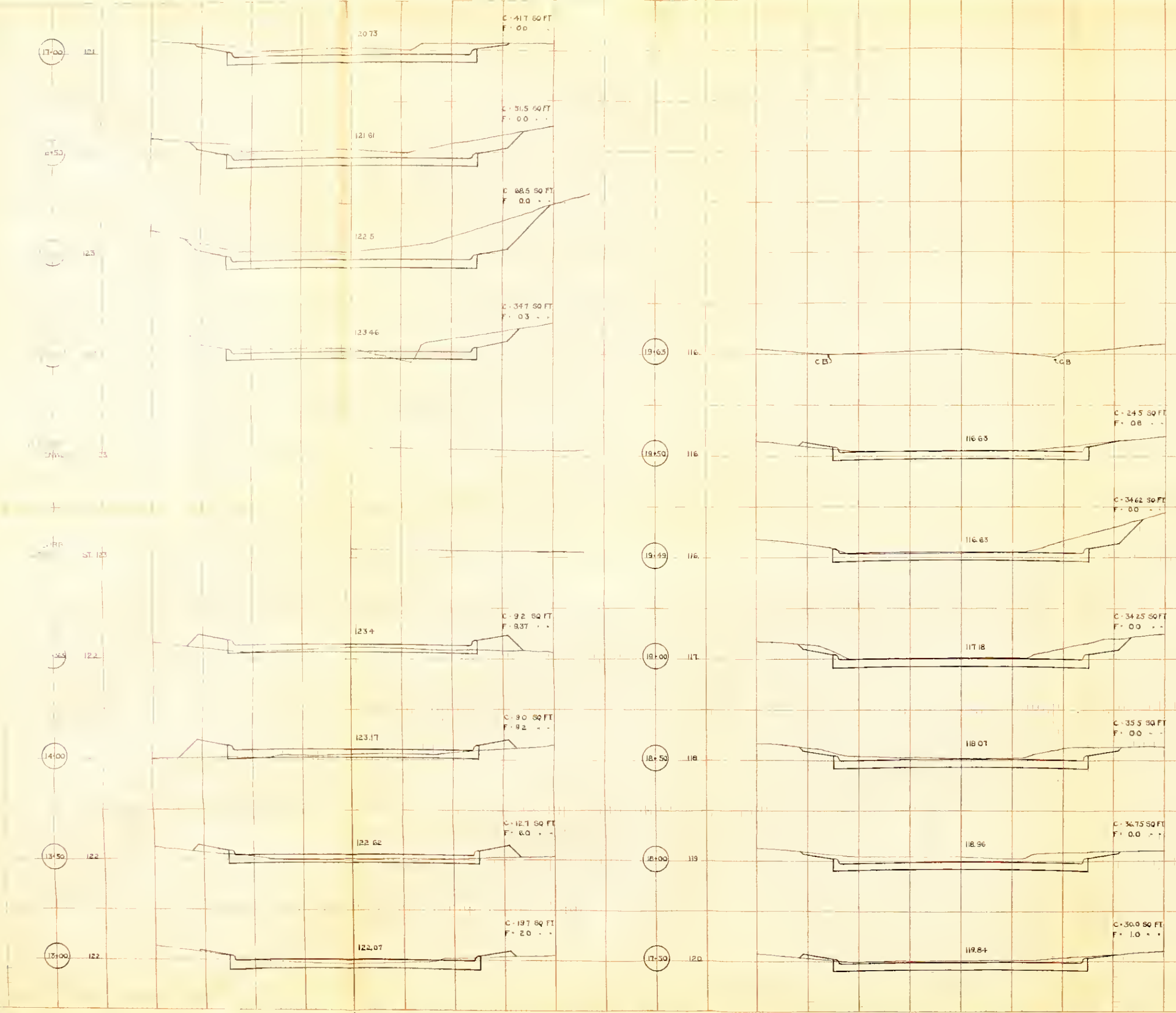
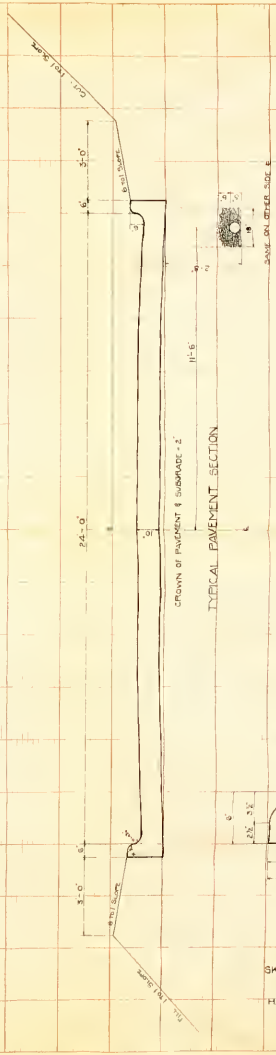


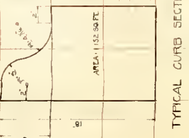
CROSS-SECTIONS OF
SKOKIE ROAD IMPROVEMENT
SCALE - 1" = 2 FT
H.E. ANDERSON — F.A. HERTWIG

SHEET No 2





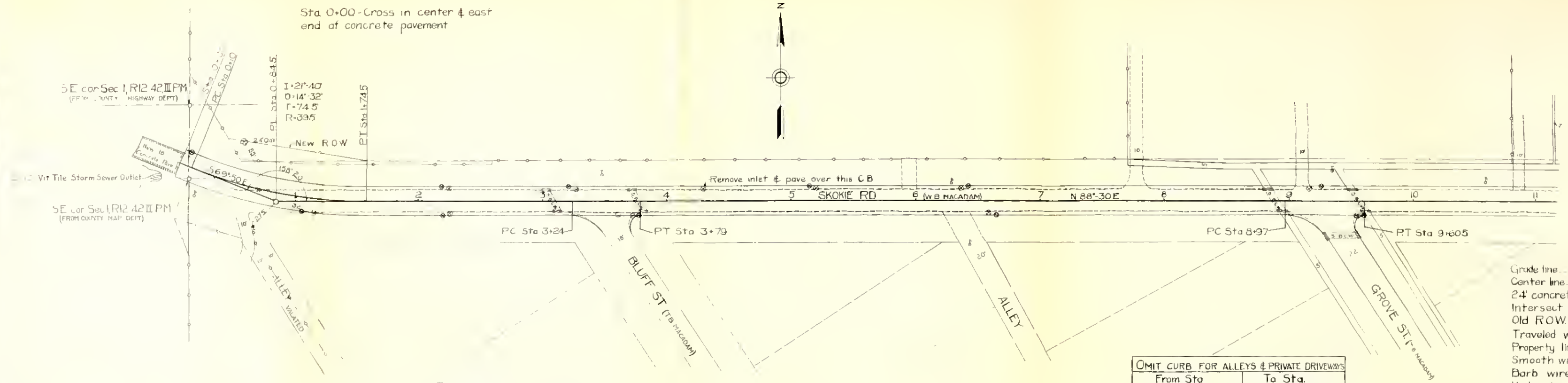
TYPICAL PAVEMENT SECTION



TYPICAL CURB SECTION

CROSS - SECTIONS OF
SKOKIE ROAD IMPROVEMENT
SCALE - 1" = 2 FT
H.E. ANDERSON — F.A. HERTWIG

100+00
110+00
150+00
LEGEND
Grade line
Center line
24' concrete & curbs
Intersect. streets
Old R.O.W.
Traveled way
Property lines
Barb. wire fence
Hydrants
Elect. light poles
old
new



NOTE - Omit tangent curbs Sta's 3+24 to 3+79 & 8+97 to 9+605. New radius curbs from these sta's to old P.C & P.T on intersecting streets as shown

B.M. Cross in center of end of concrete pavement Elev 100.00 (ASSUMED) Elev (Glencoe datum) 75.70 Use former Elev

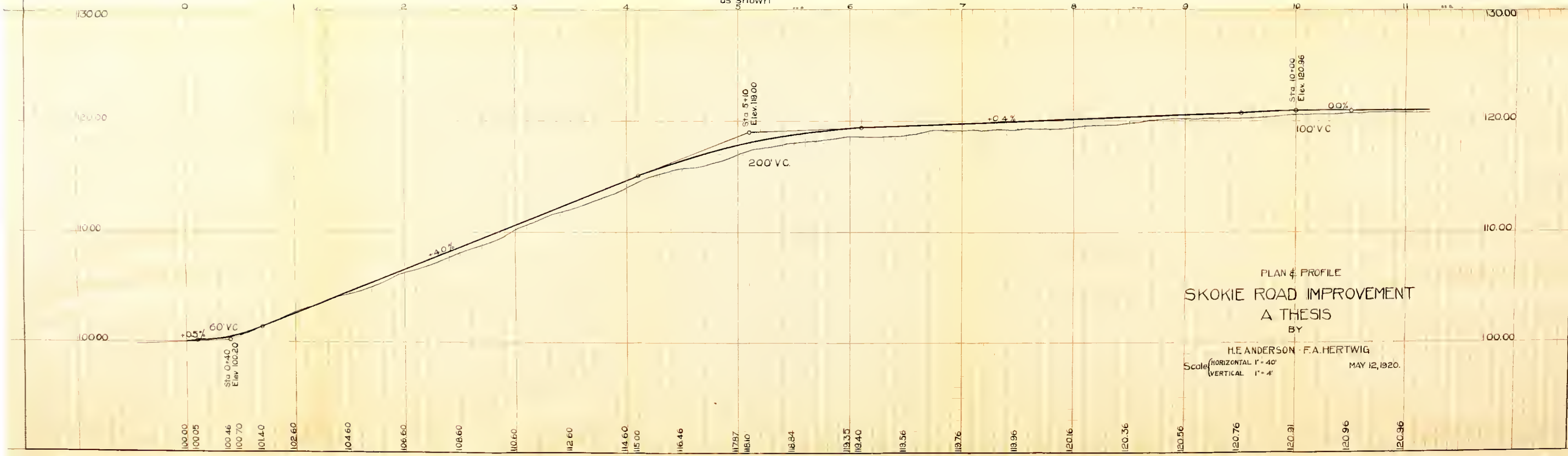
SUMMARY

Station to Station	Width of Pavement	Gross length along transit line	Length to be improved	Square Yards of Pavement
0+00-19+50	24'	1950'	1950'	1675

OMIT CURB FOR ALLEYS & PRIVATE DRIVEWAYS	
From Sta	To Sta.
0 + 62 S	0 + 76 S
6 + 32 S	6 + 56 S
7 + 69 N	7 + 83 N
9 + 02 N	9 + 16 N
10 + 805 N	10 + 94.5 N

LEGEND

Grade line	━━━	
Center line	─┼─	
24' concrete & curbs	───	
Intersect streets	───	
Old ROW	- - -	
Traveled way	- - -	
Property lines		
Smooth wire fence		
Barb wire fence		
Hydrants	♁	
Elect & tel. trans lines	♁	
Elect light poles	♁	
Sewer inlets, old	⊛	new ⊗
Sewer manholes, old	○	new ○
Brick cross walk	B.C.W.	



PLAN & PROFILE

SKOKIE ROAD IMPROVEMENT

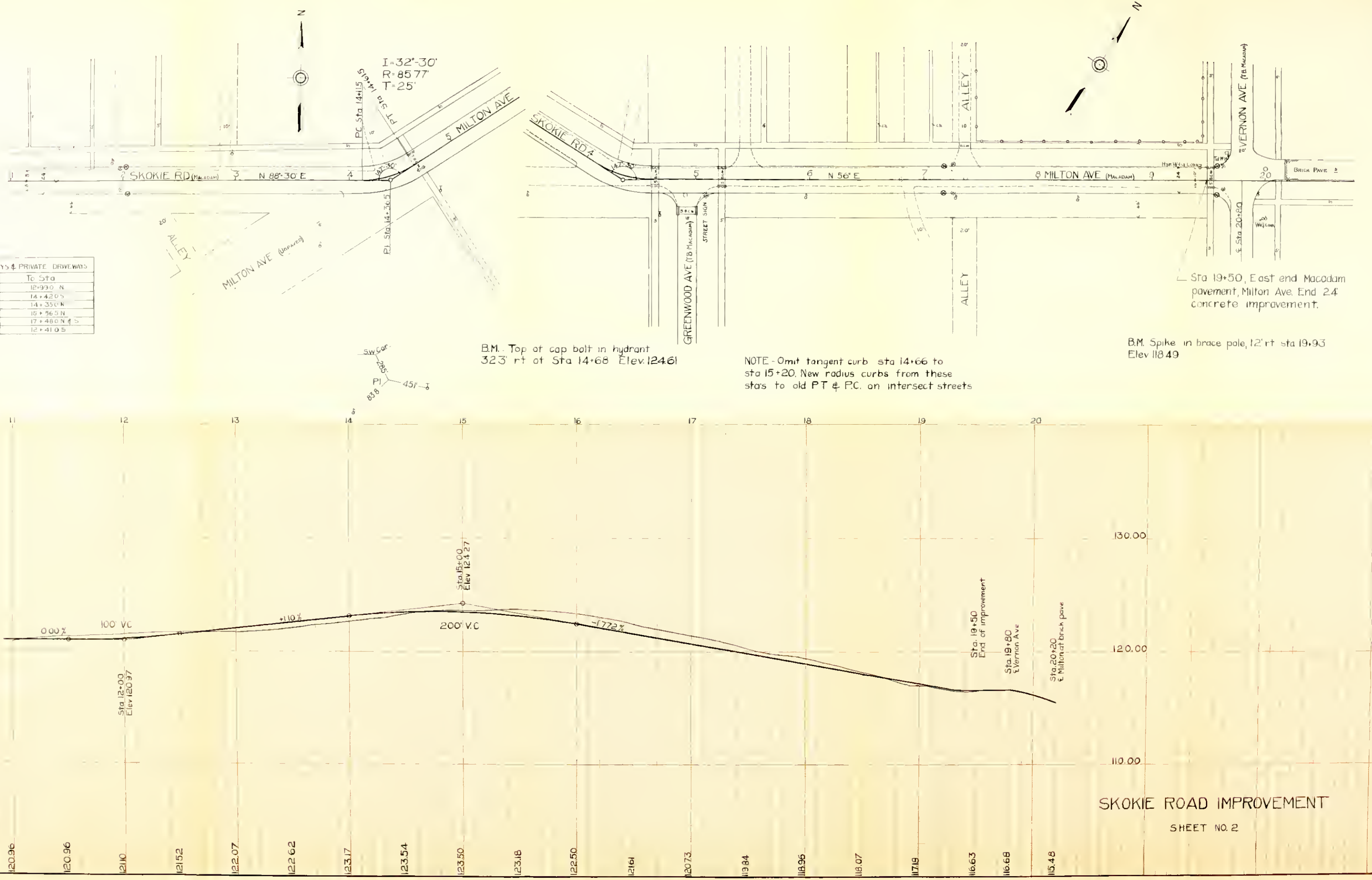
A THESIS

BY

H.E. ANDERSON - F.A. HERTWIG

Scale {HORIZONTAL 1" = 40'
{VERTICAL 1" = 4'

MAY 12, 1920.



OMIT CURB FOR ALLEYS & PRIVATE DRIVEWAYS	
From Sta	To Sta
12+840 N	12+990 N
13+880 S	14+420 S
14+210 N	14+350 N
15+295 N	16+565 N
17+240 N & S	17+480 N & S
12+160 S	12+410 S

B.M. Top of cap bolt in hydrant
32.3' rt of Sta 14+68 Elev. 124.61

NOTE - Omit tangent curb sta 14+66 to sta 15+20. New radius curbs from these sta's to old PT & P.C. on intersect streets

Sta 19+50, East end Macadam pavement, Milton Ave. End 24' concrete improvement.

B.M. Spike in brace pole, 12' rt sta 19+93
Elev 118.49

SKOKIE ROAD IMPROVEMENT

SHEET NO. 2